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SINGLE-RAIL RAILWAY.

THIS very ingenious system of transportation is due to the conception of Mr. Lartigue. It consists of a car, which, as a whole, might be likened to a pack-saddle, and which runs, through the intermedium of one or two channeled pulleys, along an iron track of rectangular form. This railway was devised especially for the transportation, in Algeria, of the alfa crop. This plant, which is used for making paper, grows abundantly in Algeria without much culture, but, for want of means of transportation, it has, notwithstanding the low cost of producing it, been hitherto almost entirely neglected. Whatever shipping was done was performed upon the backs of mules or camels, and the caravans necessarily had to be accompanied by animals carrying the food necessary for the laborers and attendants, thus making the transportation of the article very costly, as well as consuming considerable time in doing it. A radical change in this mode of transportation was effected about twelve months ago, upon the elevated plains of South Oranais, in the adoption of the system of railway which we are about to describe, and which is working to the entire satisfaction of the stockholders.

The rails are placed at about 0·8 m. above the ground. They are each about 3 meters in length, are joined together by fish-plates, and are supported, each of them, by two U-shaped standards. One laborer, with an assistant, is capable of laying several hundred meters of them per day.

Each rail weighs 13 kilos, and the two supports and the foot weigh 14.

The alfa car consists of a small cast iron frame with bronze bearings and automatic lubricating cups, and a channeled pulley keyed to a steel axle. To this frame are fixed two U-shaped irons, or two angle irons, for holding the load. These irons are held apart at a proper distance by cross-braces of iron to which is affixed a metallic meshwork.

The entire car is very light, and weighs only from 30 to 34 kilos. As the center of gravity is beneath the point of suspension, there is no danger of the car upsetting. A difference of twenty kilogrammes between the weight of one side and that of the other causes the apparatus to incline slightly without destroying its equilibrium or increasing the

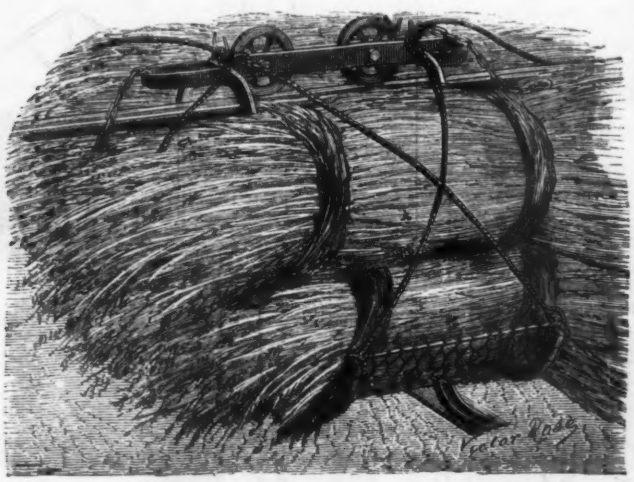


FIG. 1.

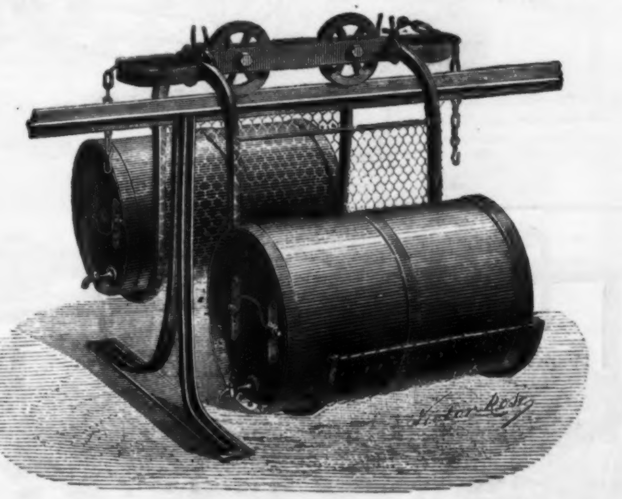


FIG. 2.

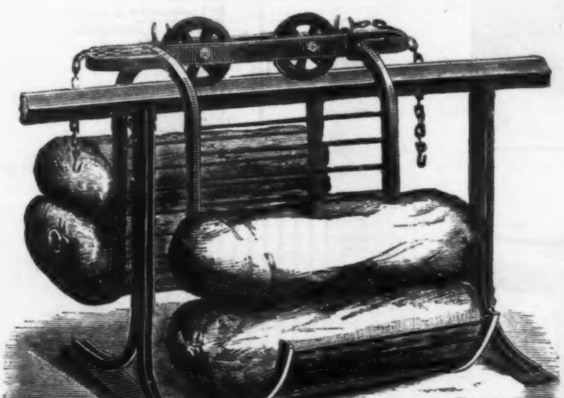


FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

SINGLE-RAIL RAILWAY.

friction. The railway is so simple that it may be put down or taken up very easily and with remarkable rapidity. The ground does not have to receive any preparation, as the flexible rail follows all its irregularities; and a simple pressure given the rail by the body of the workman suffices to bend it and at once form any desired curve without the necessity of calling in the aid of a blacksmith.

In the sandy parts of Algeria it would not have been practicable to lay rails upon the surface of the ground, for the sands, upon being shifted by the violent winds that prevail there, would have quickly covered up the track. But, in the system under consideration, wind and sand have no influence, since the rails are placed at a sufficient distance above the earth to prevent it.

It is evident, however, that this mode of transportation could not be applied in a country cut up by roadways.

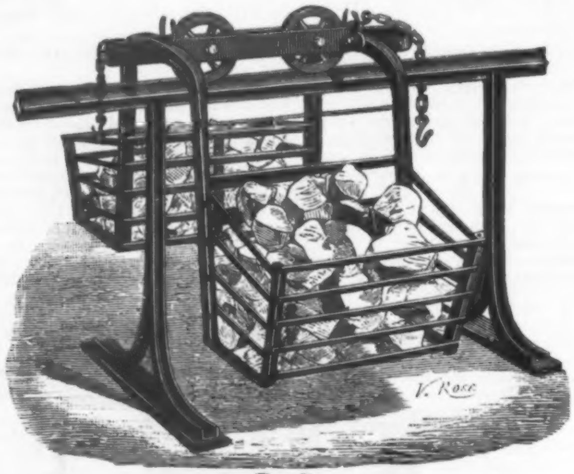


FIG. 7.

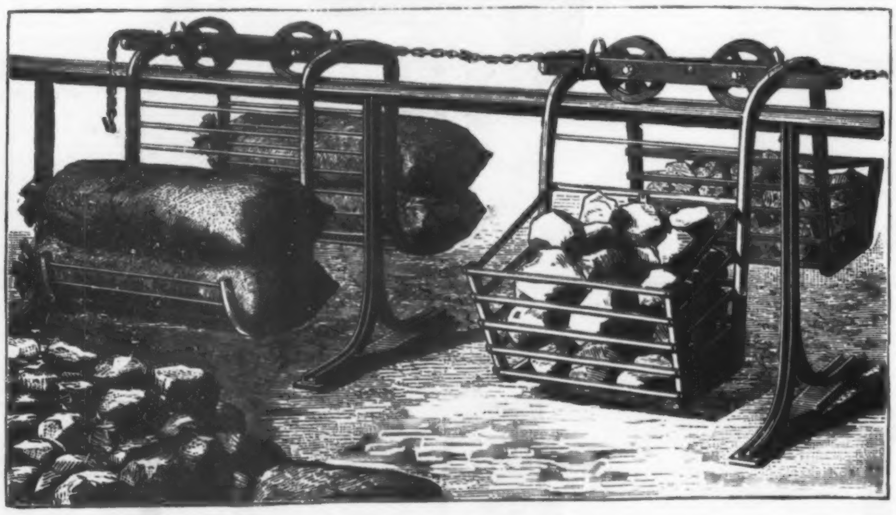


FIG. 8.—MODE OF COUPLING THE CARS IN TRAINS.

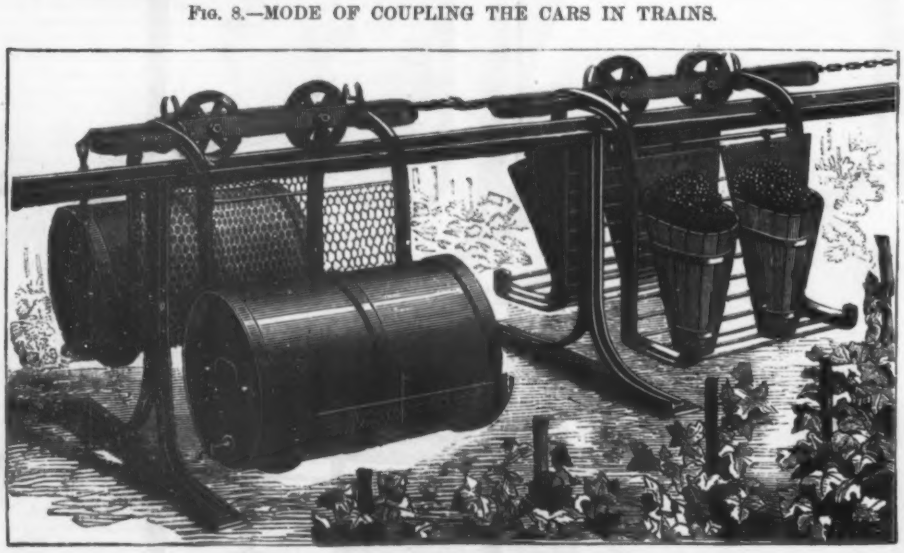


FIG. 9.—MODE OF COUPLING THE CARS IN TRAINS.

SINGLE-RAIL RAILWAY.

But, on another hand, it is capable of receiving numerous applications in the larger industries, and especially in agricultural operations.

The following are some of the advantages possessed by this ingenious system:

(1.) Its cost is lower than that of any other system of transportation hitherto known.

(2.) It is easily and quickly put in place, a force of six men being capable of laying four kilometers per day.

(3.) It does away with the necessity of switches and shunts, of curves prepared according to a given radius, and of turntables, etc.

(4.) It requires no keeping in repair, as the height of the rail above ground (0·8 m.) protects it against sand, mud, grass, etc.

(5.) As it is possible to form curves of double radius in it instantaneously, the laying of the rails costs less than it does in any other system.

(6.) The cost of traction is low, one draught-animal being capable of drawing double the weight that he could upon an ordinary two-rail railway. On the road in operation in Algeria, one camel draws without difficulty thirty cars connected together by a simple coupling link.

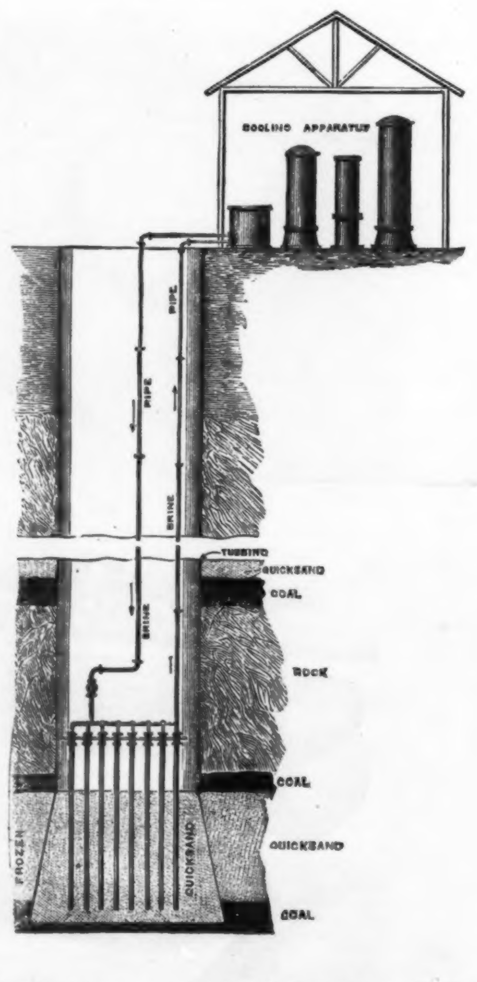
The system also permits of one or two rails being quickly removed to allow a passageway for carts, droves of cattle, etc. According to the application and the weights to be transported, the cars are made of different shape, strength, and length.

We illustrate a few of them herewith. Fig. 1 represents a type for the carriage of alfa, cereals, forage, bamboo, wood, etc. Fig. 2 shows a type provided with movable metallic vessels for carrying water, wines, oils petroleum, etc. Fig. 3 exhibits a type designed for the carriage of merchandise in bags, such as wheat, rice, corn, oats, potatoes, etc. Fig. 4 represents a car for carrying vintagers' baskets. Fig. 5 shows a type designed for the carriage of boxes and packages of all kinds. Fig. 6 shows a car provided with tilting boxes for the carriage of pulverulent materials, fine coal, earth, chalk, etc. The same type modified, with openwork bottom and hinged side, is applied in the carriage of beets from silos to the rasping mill. Fig. 7 represents an openwork type for the carriage of coal, limestone, bricks, etc.

We have also seen a type of car designed for carrying wounded soldiers to the outposts. A mattress laid upon wooden slats, beneath which, if desired, springs may be placed, forms a couch that prevents the patient from being disturbed by the gait of the draught-animal. The car is surrounded by an impermeable fabric that serves to keep out the rain and sun. Figs. 8 and 9 show the appearance of the cars when connected in pairs.—*Chronique Industrielle.*

SINKING SHAFTS THROUGH QUICKSANDS BY FREEZING.

THE question of sinking shafts with certainty and expedition through water-bearing strata is one which has seriously engaged the attention of engineers both in this country and abroad for a great number of years. Notwithstanding, however, that much has been accomplished, it must be confessed that the methods in use up to the present time still leave much to be desired, both on the score of economy and outlay and certainty in result. On the Continent especially large sums of money have been outlaid in struggling against watery deposits of sand and gravel, met with generally at too great a depth to admit of the application of the compressed air system; and in some cases, after the expenditure of many thousands of pounds in futile pumping, some other method has ultimately to be resorted to in order to overcome the difficulty. Hitherto, in addition to the "Plenum" process, which is only applicable when the air pressure is not required to exceed some four atmospheres, the system most generally employed has been to sink watertight cylinders of iron, or of masonry shod with iron, by loading them from above and forcing them down by screws or by blows from a falling weight, while the material is removed from the inside by hand or revolving dredgers, length after length being added to the cylinders as the sinking proceeds. Simple as this process appears to be, it is in some cases extremely difficult of application, while, in others, it is not too much to say that it has signally failed.



To insure success in cases where other means have failed various special plans have been devised, among which we may mention the Kind-Chaudron system, which has been fully described in the *Transactions* of the Institution of Civil Engineers, and the plan adopted by M. Chavatte, which is detailed at length in the *Bulletin de la Societe de l'Industrie Minerale*, besides one or two other arrangements which have not been applied beyond the one special case for which they were designed. Granting, however, that with one or other of the systems we have enumerated a shaft can be successfully carried through a water-bearing stratum, it is often only accomplished after an enormous expenditure of time and money, the proprietors of the mine being handicapped with this extra amount of capital, as compared with their more lucky neighbors, who have perhaps done their sinking under less unfavorable circumstances. Any process, therefore, which is both certain in its results and comparatively cheap in application is certain to be received with great satisfaction by all those concerned in the sinking of shafts, and we therefore give the following description of a new method recently invented by Herr Poetsch, mining engineer, Aschersleben, which is now being introduced into this country by Messrs. A. & E. Cohen, of Basinghall street, E.C., and which seems to us likely to be of great practical value. It consists in actually freezing the quicksand or running ground to a hard, solid mass, through which the shaft can then be sunk in the ordinary way without pumping, the external circular wall of ice left outside the excavation giving sufficient protection against influx of water, sand, or gravel, until the permanent masonry or iron lining is got into position. To accomplish this, after the shaft has been brought down to the level of the quicksand, a number of bore-holes are carried down to the solid ground by means of a sand pump. These holes are spaced about a yard apart, and are placed in circles,

the outer one approaching as nearly as possible to the circumferential line of the shaft when finished. The bore-holes are then lined with iron tubes closed at the bottom, within each of which is a smaller concentric tube of copper open at the bottom and connected at the top to a main pipe communicating with all the other copper tubes and extending to the top of the shaft. The upper ends of the outer iron tubes are also connected to one main pipe, which, like the other, extends to the surface of the ground. Through these pipes brine, consisting of a solution of the chlorides of calcium and magnesium in water—which has a freezing point of about 36 deg. below zero Fah.—is caused to circulate by a small force pump driven by an engine, its course being down one of the mains and the internal copper pipes, and back through the surrounding annular spaces and the other main to the top of the shaft. At the surface is placed a cooling apparatus, preferably of the ammonia type, the refrigerator being inserted between the two lines of mains, so that the brine in its flow is continuously cooled to a temperature of about 15 deg. below zero Fah. before its passage down the shaft into the bore-holes. In this manner heat is rapidly abstracted from the quicksand or other running ground, which is thereby frozen into a hard, solid mass after a period, it is stated, varying from fifteen to twenty days, according to the size of the shaft and the conditions under which the apparatus is worked, the freezing being continued till the solid block extends well beyond the space to be occupied by the shaft and its lining. The excavation is then carried on as through solid ground, the masonry or iron lining being introduced as the cutting proceeds, in order to prevent the surrounding ice wall from breaking in from the external fluid pressure.

The annexed engraving will show without further explanation the manner in which the process is applied, the arrangement being that recently adopted in the successful sinking of the Archibald shaft of the Douglas coal mines at Schneidlingen. In this, the first practical application of Herr Poetsch's system, a bed of running sand about four meters thick had to be pierced. Twenty-three bore holes were employed, and the freezing process was completed on the 10th of August last, on which date the sand had become a mass of such hardness that it was with considerable difficulty that pieces could be broken off. The shaft was then completed in the usual way without stays and without pumping. To expedite the work it is proposed that, when admissible, the shaft shall be sunk down to the natural level of the water of larger dimensions than actually required for the working, in order to permit of an outer ring of bore-holes being made in the ground outside the lining of the shaft, in which case it is estimated that the freezing may be accomplished in from ten to fourteen days.

In the present stage of the process it is, of course, impossible to ascertain with any great degree of accuracy the cost at which the freezing of such a large open mass can be accomplished, though some idea can, perhaps, be formed by comparison with the work actually done by refrigerating apparatus in the manufacture of ice. Assuming that what is called a 10-ton machine be employed, this would be capable, when applied in the usual way for ice making, of forming ten tons of ice in twenty-four hours, at a cost of about 8s. per ton, exclusive of interest on capital, and with coal at about 12s. a ton. Probably in freezing a quicksand only a third of this quantity of ice could be calculated upon, or, say, 3½ tons per twenty-four hours. Taking the block to be formed at 22 ft. diameter and 13 ft. thick, and assuming one half of the quicksand to be water and the other half solid matter, the quantity of ice may be roughly taken at 70 tons. This, at 3½ tons per day, would take twenty days in its formation, the working expenses per ton being three times that in ice making, or say a total of £84. To add to this there would be the rent of the installation and the cost of the special pipes and appliances, which would have to be made to suit the circumstances of each case, as well as a sum for patent rights and charges; but allowing handsomely for these, it will be seen that the total cost in such a case as we have taken must be comparatively insignificant compared with that of the usual methods in which enormous sums have been spent in pumping alone, and this will be true even if the time occupied in freezing is very much greater than is now stated to be the case.

It is, of course, a matter of speculation at the present time to what extent Herr Poetsch's plan can be applied in this country, but it must be obvious that there are many instances in which it is likely to prove of the greatest value, and we have therefore not hesitated to bring it before our readers. The principal points in favor of the system appear to be not only in the cheap and expeditious method of making shafts and cuttings through quicksand or running ground, but in the fact that it seems to give an almost absolute certainty of result, at a cost which is not only comparatively small, but which can be very closely ascertained beforehand. In this way the risks attending the sinking of new pits should be minimized.—*The Engineer.*

IMPROVED SAFETY VALVE.

THIS apparatus is manufactured by Mr. T. C. Fawcett, of Old Victoria Foundry, Manor Road, Leeds. It will be seen that the valve itself is an ordinary well-constructed dead-weight safety valve, with separate floats and internal levers, to insure operation as an alarm under conditions of too high or too low water level. The valve also operates in an entirely novel way (independently of the water levels) as a high pressure safety valve when it relieves the internal boiler pressure. The valve is contained in a lock-up box, placed on the top of the boiler, and all its parts are entirely out of the control of the fireman. When the steam rises above the fixed working pressure of the boiler to the slightest degree, it passes into the box, from which it is conducted into the interior of the boiler through a pipe which divides into two branches, which are respectively screwed into the crown of each flue directly over the hottest part of the fire. Thus, when the steam blows off at the safety valve, it passes directly on to the top of the fire, instead of escaping into the atmosphere, and it, therefore, has the effect of damping the energy of the fire without the firemen having to resort to the objectionable plan of opening the fire doors and admitting cold air to the flues. The effect is certain and effectual, and, moreover, the noise of the jets is an intimation to the fireman that no more fuel is required for the time. The moment the steam ceases to blow off into the lock-up box the fire brightens up again without attention. The same effect is observed when the water is too high or too low, in which cases the fireman must attend to his feed; but, should he neglect to do so, in case the water is too low, the ingress of the steam into the flue prevents the danger of the flue plates over the fire coming down through over pressure. Thus, by the application of this invention, danger is averted, noisy blowing off of steam into the atmosphere avoided, the attention of the fireman secured, and economy effected by the exclusion of cold air from the furnaces, and the admission of hot steam in its stead. Fig. 1 of our engravings represents a transverse, and Fig. 2 a part longitudinal section of a double flued Lancashire boiler, fitted with the apparatus. In these views, A is the valve case fixed to the top of the boiler, and containing the valve and the end of the outlet pipe to the furnaces. B is the outlet pipe to convey steam to the furnaces, C the dead weight on the safety valve spindle, D the low water float, E the high water float, F the lever with floats at the ends for lifting the valve at high or low water, and G is the boiler furnaces. These valves are already in use at several large works, and are reported to be giving every satisfaction.—*Iron.*

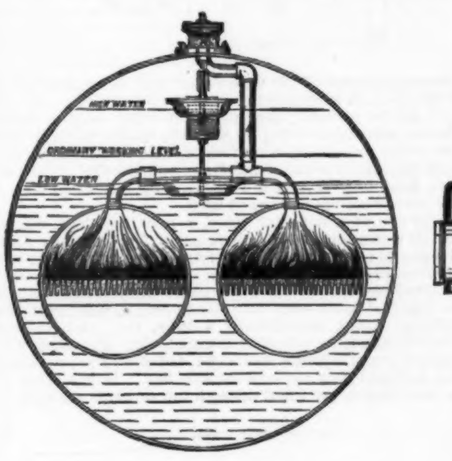


FIG. 1.

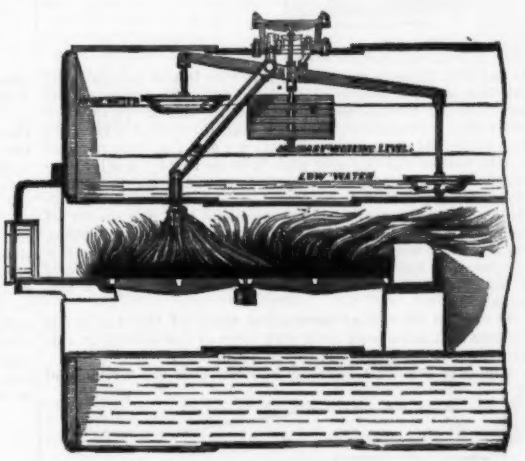


FIG. 2.

SAFETY VALVE AND FIRE EXTINGUISHER.

LATHE FOR MANUFACTURING SPOKES.

THIS new machine, which has been specially constructed by Mr. Robinson for the manufacture of wagon spokes and hammer handles, consists of a cast-iron frame, A, which carries two double-centered puppets, one of which, B, is stationary, while the other, C, is movable. This latter, which is adjusted in a groove in the table, is capable of being slid longitudinally, and of being regulated according to the length of the piece to be shaped. The latter is held in place by a mandrel, *b*, and a movable center, *c*, which is maneuvered by means of a lever. The position of this center being once determined, it is fastened by means of a threaded collar which prevents any displacement of the wood while the machine is running. The piece designed to serve as a model (which must be either of bronze or cast iron) is fixed by one extremity to the mandrel, *b'*, and by the other to the center, *c'*. The mandrels, *b* and *b'*, are fixed to the horizontal spindles of the head-stock, and these are connected by two gear-wheels, B' and B'', and obtain their motion from a pinion keyed upon the same axle as the cone, D. This latter, which has three velocities, communicates by belt with the cone, E, which is fixed upon the same shaft as the two pulleys, F and F'. These pulleys, one of them fast and the other loose, are actuated by the small pulley, G', keyed to the shaft, G. This latter is actuated by the general shafting through the intermedium of the pulley, H. In front of the lathe there is mounted a support, M, which rests upon the shaft through a socket at its lower extremity, and which is capable of being moved longitudinally along the guide, A'. This support carries a fixed nut, which is traversed by a screw, I, upon whose extremity is mounted a loose gear-wheel, J, which is set in motion by the wheel, B''. Upon this same screw, J, there is mounted a gearing sleeve, K, which has straight teeth, and which is controlled by a fork, L', and a rod, L, that carries two movable tappets, *l* and *l'*, whose position may be regulated at will. When the support, M, abuts against one of these tappets, the rod, L, acts upon the forked lever, L', and this latter pushes the sleeve, K, and thus changes the direction of rotation of the screw, I, and consequently the direction in which the support, M, is moving.

The upper part of this support forms a slide, and receives a carriage, N, which carries the horizontal shaft, O, to which are keyed the tool-carrier, P, and the pulley, Q. This latter communicates by belt with the pulley, *g*, whose hub is provided with a piece that slides in a longitudinal groove in the shaft, G, thus permitting the pulley, *g*, to follow the motion of the support, M, without ceasing to be dependent upon the shaft.

Besides the rotary tool-carrier, the carriage, N, carries a roller, R, which is mounted upon a fork that is provided with an adjusting screw and that may be moved backward or forward by means of a hand-wheel, *r*.

The lathe operates as follows: The model and the piece of wood to be shaped having been fixed in place upon the centers and mandrels, the belt is shifted from the loose pulley, H', to the fast one, H, which brings about all the motions of the lathe. The wood and the model are interdependent, and are given the same rotary speed, since they are set in motion by the two wheels, B' and B'', which latter are of the same diameter and gear with one another.

The model, in revolving, repels, through its projecting parts, the roller, R, and consequently the carriage, N, and the rotary tool-carrier, P. When the projecting part ceases to be in contact with the roller, the carriage returns to its initial position under the action of a counterpoise, S, which is attached to its foot by a cord, so that the carriage and tool-carrier are given a continuous backward and forward motion that depends directly upon the form of the model.

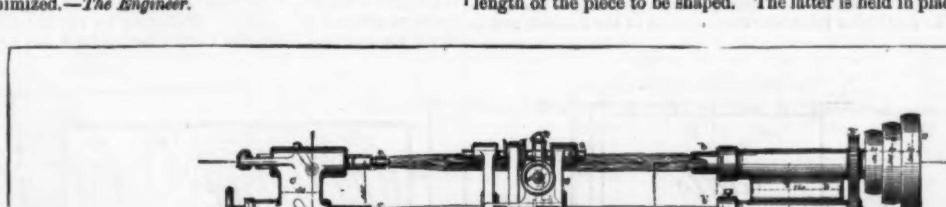


FIG. 1.—FRONT VIEW. (Scale of 0·125 to 1.)

FIG. 2.—SIDE VIEW. (Scale of 1·25 to 1.)

REPRODUCING LATHE FOR MANUFACTURING WAGON SPOKES.

The form is thus exactly reproduced in the wood by the four blades of the tool-carrier.

By means of the mechanism described above, the support, M, moves longitudinally, and the tool shapes the wood until the tappets, l or l', are abutted against, and a change of direction is effected.—*Annales Industrielles.*

SMOKE BURNING FURNACES.

By FRANK C. SMITH.

SMOKE burning, or smoke preventing rather, in locomotives is attracting no little attention at present in this country, owing largely, perhaps, to the stringent laws on the subject enforced by some cities against the nuisance, as well as a desire by railroad managers to enhance the comfort and cleanliness of traveling. It will not be far from the truth

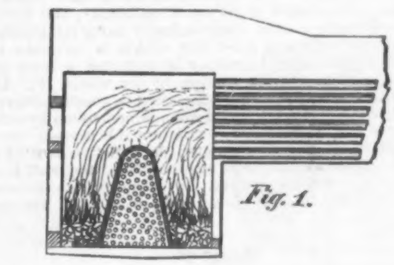


Fig. 1.

to say that there is no successful device in use generally by our railroads for smoke prevention, although strong claims are made for several, and the reasons for this are plain when the varying conditions, the fact that dimensions, etc., are necessarily fixed ; rapid combustion ; and the want of time on the part of the engineer and fireman to pay much attention to the adjustments necessary to meet the varying conditions that the combustion of coal is subjected to in locomotives. In stationary work the problem is much easier of solution, as no restrictions of space, or the rapid combustion, etc., are met with. The most popular devices used for this purpose on locomotives are probably the brick arch and hollow stay bolts, and occasionally Clark's steam jet is met with.

It may be interesting to examine some of the numerous devices that have been used with more or less success in this direction, in both this country and England.

The first "smoke burning" device that the writer had

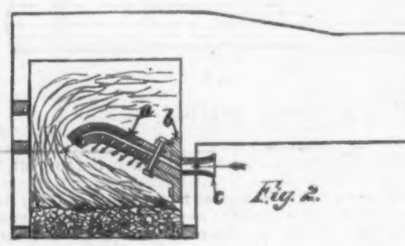


Fig. 2.

any practical acquaintance with, was called the "bee hive grate," and is shown in Fig. 1. It consisted of a cast iron cone, *a*, full of holes, bolted to the grates. Its section was not a circle, the sides being flattened so as not to occupy too much of the grate area. As long as it lasted it was a great success over the ordinary construction. The air for the ignition of the gases was liberated at the right point—near the surface of the fire, with the result of filling the fire box with a solid sheet or body of flame. Unfortunately for this as with most other similar devices, its life was exceedingly limited, as from ten to twenty days burned it out. For several months it was replaced, but the novelty soon wore off, and it was abandoned. While it was in use no smoke was visible except when green coal was fired, and then the volume of smoke was greatly mitigated. The economy of the engine was not noticeably improved by its use. Fig. 2 represents an improvement on the former. In this figure, *a* shows a section of a fire clay arch, formed with a central channel out of

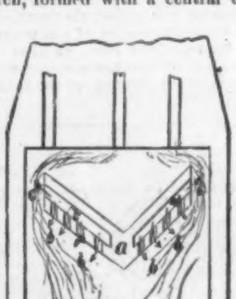


Fig. 3.

which openings, *d*, lead for the distribution of the air, which was taken in by several bell mouthed castings, *e*, extending through the front leg as shown. The arch, *a*, extended clear across the fire box and was fastened by cast iron angle plates, *b*, *b*, and bolts. It was a much better arrangement than that in Fig. 1, as it lasted much longer and produced about the same results. It was abandoned on account of the fusing together of the openings, *d*, the filling of the channel and openings with sparks and clinkers, and the occasional breaking off of the arch itself from its weight and jarring of the engine. Fig. 3 represents a top view through the fire box with a device which, I think, is now being tested with fair prospects of a reasonable success. It consists of heavy fire clay or brick pieces, *a*, shaped as shown. The first one lies on the grate, and with four more on top of it reaches the crown sheet. These are retained in place by lugs projecting from the bottom of each piece into depressions of the next lower. A steadying plate at the crown sheet secures the whole. It will be seen that this forms an angling wall from grate to crown sheet, across the face of which the gases must pass, reaching the flues by passing around the corners, *c*, *c*. A channel, *d*, extends through each brick vertically, out of which openings, *b*, *b*, are provided for the passage of air from the grate to the gases as they lick the face of this wall. The result of the device has been quite satisfactory, and it is believed that openings will not fuse together, owing to the bulk of clay. The filling of the channel, *d*, with sparks is, however, to be feared. A longer fire-box would be required with this arrangement, owing to space occupied by the device, which, as will be seen, occupies considerable of the grate. It is, or was, tested on a shifting engine, and the loss of the grate surface was not so noticeable. Fig. 4 represents the ordinary brick arch so generally used. The blocks are held in position by four two-inch pipes tapped into the crown sheet and throat sheet as shown; *c* being the pipe, and *a* the brick or blocks of fireclay.

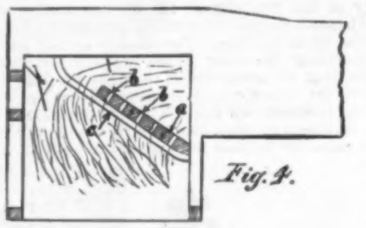


Fig. 4.

An acquaintance of the writer's has had exceptional success with this arch in connection with the extension smoke arch as a smoke palliator, the reduction being very noticeable. He had one engine fitted up with the blocks through which numerous holes, *b*, *b*, were formed, and it was found to aid very materially in the reduction of the smoke. The excessive heat, however, soon fused the openings together, and the holes were not afterward used.

The use of a deflector plate, *a*, over the door, directing the air down into the fire, originated from firemen placing the shovel as shown in dotted lines after each firing, which resulted in reducing the smoke. These plates are generally made of cast iron or old boiler plate, and as would naturally be expected, soon burn out. The plate, *a*, has taken many different forms, occasionally a tube, etc., and frequently hinged so as to be raised or lowered, etc. Fig. 6 shows the application of Clark's steam jet, the figure representing a top sectional view through the fire box. Hollow stay bolts or thimbles, *a*, are fitted through the side legs generally and

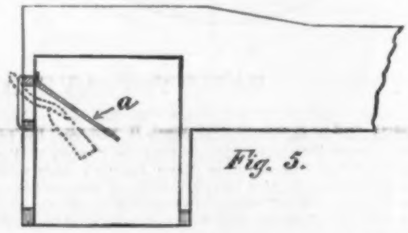


Fig. 5.

occasionally on the back and front leg as well. A gas pipe, *c*, is located as shown and provided with nipples, *b*, opposite each thimble. A connection is made with the steam space of the boiler with the pipe, *c*, and regulated with a globe valve, so that by allowing steam to enter the pipe, *c*, it escapes from the nipples, carrying large quantities of air into the fire box. The supply of air is to a certain extent under control, by throttling the globe valve. The location of the thimbles is generally about 7 or 8 inches from the grate. Fig. 7 shows this device half size ; *a* being the thimble, *c* the pipe, and *b* the nipple, which is conveniently made by tapping a piece of brass wire into the pipe and drilling a hole through the wire. The action of this is similar to the injector and gives good results when carefully handled, and will be referred to hereafter. Fig. 8 shows the "water table" principle so extensively used a few years back. David Matthews, who ran the De Witt Clinton, one of the pioneer engines in this country, claims to have first used the water table principle. Mr. Matthews is still alive and is superintendent of the San Francisco gas works, I believe. The Jauriet style consisted of the table or leg, *a*, communicating with the front and side legs. It gave general satisfaction in connection with hollow stay bolts and perforated fire door. The Buchanan table was an extension of the Jauriet, and is

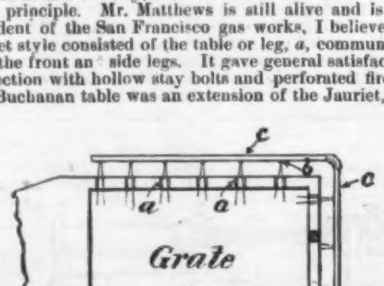


Fig. 6.

shown by the dotted lines, *b*. It opened into the four legs of the fire box and was provided with an opening, *c*, for the passage of the gases to the flues, the upper chamber, *e*, forming a combustion chamber. Mr. Taylor, of the Old Colony road, used with considerable success a table shown by *d*, which opened into the side legs, and was free from the front leg to allow of any cinders carried to the top of the table returning to the grates as per the arrow. This table was also curved downward in its length to allow of the escape of the steam generated in it. Fig. 9 is a construction which was intended to revolutionize coal burning but which was a lamentable failure. The fire box was carried forward into the sheet of the boiler, shortening the flues to about six feet. A leg, *a*, was first used, but soon filled up with mud. The engines failed to steam, and it was proposed to use openings, *c*, to ignite the gases in the front chamber. It was also suggested that the flame had too short a cut to the flues, and a leg, *b*, was proposed. Although extensively used it was finally abandoned on account of the filling up of the leg, *a*, and its poor steaming qualities. Fig. 10 shows Cudworth's double fire box, successfully used in England some years back. The grates were slanted downward from the back. A central leg, *a*, divided the fire box into two compartments. The leg, *a*, did not extend to the flue sheet, but left an opening or passage way, *b*, throwing the two fire boxes into communication at the front end. The fire boxes were fired alternately through the two doors, *c*, *c*, in the back view. Coal was fired into the back part of the grate as shown at *e*, and worked forward as it became thoroughly ignited and devoid of smoke. The gases formed from the green coal at *e* were burned in passing over the hotter portion, *f*, as well as by the intermixture of heat and flame from the opposite fire box, which being fired alternately,

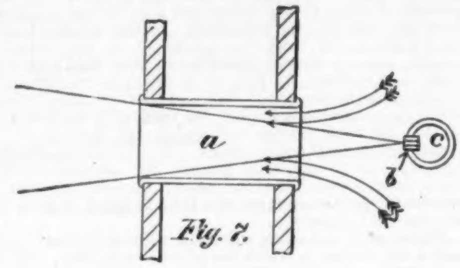


Fig. 7.

was supposed to be filled with red hot coals. It was quite successful, and will be referred to hereafter. Fig. 11 was an English invention by Deurance, and was called the "Argand furnace."

The fire box proper, *a*, was in communication with the combustion chamber, *e*, by means of the short tubes, *b*, where the gases were met by the inflowing air through *c*, escaping from the perforated top. A baffle plate, *d*, served to facilitate the mixture of the gases. Fig. 12 is Head's invention, an American. It represents a top view through the fire box. *a* was a central leg dividing the fire box into two portions ; *b* a damper plate hung at *c*, around which point it could be rotated by suitable connections to the cab, so as to close either fire box from access to the flues, except through the other fire box. It was necessary to fire the fire boxes alternately, thus : suppose the fire box, F, to have a bed of bright red coals, the damper, *b*, would be placed in the position shown, and the fire box, E, fired with green coal.

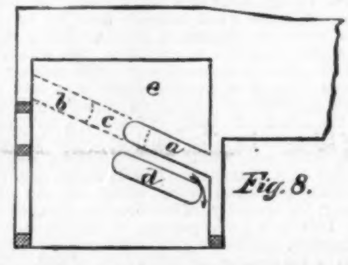


Fig. 8.

The gases from this fire box would be compelled to pass around the leg, *a*, as shown by arrows, over the hot coals in F, and then to the flues. When the coal in E became red hot, the damper, *b*, would be shifted to close fire box, F, and fresh coal fired to the latter, the gases of which would find an outlet through fire box, E, and over the hot coals contained on its grates.

Fig. 13 is one of several forms of double grates. Green coal fired into the upper grate was pushed into the lower grate as it became red hot; air passing through the lower grate and between the two, as at *e*, was heated, mingling with the gases from the upper grate and igniting them. The gases were forced around the leg, *a*, and met with an additional supply of air at *c*, through the pipe, *b*. Fig. 14 shows an arrangement of an old idea—downward draught, which I believe is being tried now. Coal is fired into the chamber, *a*, and supplied with air through and at each side of the fire door. The force of the exhaust draws the gases down through the fire itself—burning them, it is claimed, when they find their way to the flues as shown. There are many other devices prominent at one time, such as the "Boardman," which was a square box connection on the under side of the sheet of the boiler, fitted with upright flues, down one set of which the gases passed and up another. Provision for the admission of air was provided. Dimpfel's boiler had no back flue sheet,

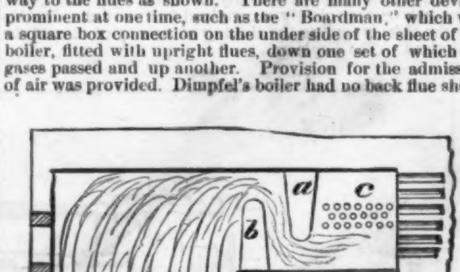


Fig. 9.

the flues extending back and curving upward into the crown sheet, the gases escaping around them in the space ordinarily occupied by water.

Having shown some of the many "smoke consumers" in use at various times, it will be in order to discuss some of the trials they were submitted to, with the general principles underlying the successful prevention of smoke.

The fault with the "Argand furnace," Fig. 11, in practical use was the cooling of the gases by passing through the small flues, *b* (which were for the purpose of dividing the gases into streams the better to mix with the air), to a temperature at which the entire bulk of the gases would not ignite, and but partial combustion resulted. The results as a whole were however considered favorable.

Cudworth's fire box, shown in Fig. 10, on trial gave it is said very fair results, and would have done much better, if the

space, *b*, were longer, or a baffle plate used, so as to insure a better mixture of the gases and air. Head's arrangement, in Fig. 12, and Cudworth's it is asserted are the only practical arrangements for alternate firing.

Clark's steam jet, shown in Fig. 6, gives very good results when careful firing and handling is had; and with any device for this purpose, good results without careful attention cannot be expected, and this attention is difficult to get from the average engineer and fireman, whose time is too fully occupied by other matters.

The necessary conditions for the complete ignition of the gases appear to be a sufficiency of time, space, heat, and air.

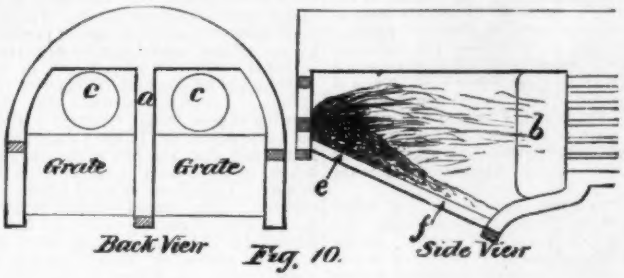


Fig. 10.

Ordinary illuminating gas is made by heating coal in a closed vessel. The gas thus given off is that which in a locomotive is necessary to supply the necessary air and heat to effect combustion. This gas unmixed with the air will not burn, but when allowed to escape from a burner and supplied with the air in the room it ignites if a flame is touched to it. If a burning gas jet is exposed to a draught from an open door or window, it smokes because the supply of air is too great; the heat is sufficient, and it therefore appears that a too plentiful supply of air is as detrimental as too little. It is also stated that if coal gas and air be placed together in a vessel, it will take considerable time for it to mix thoroughly unless assisted by violent agitation or mechanical means. When the great velocity of the gases and the short time occupied by the gases in passing from the coal to the flues is considered, the difficulty of mixing the air with it will be appreciated. It is necessary to mix the air with the gases as close to the fire as possible in order that the mixture may have sufficient heat to allow of burning. All smoke preventing devices which allow of the admission of air at the top of the fire box or in another chamber are necessarily ineffective to a greater or less extent owing to this fact, that is, the mixture is too cool to burn. Gas is given off in variable quantities, depending on whether the coal is green—half, two-thirds, or more burned—and the supply of air must be in proportion. Hence for perfect combustion of the gases and without smoke, the supply of air should constantly change, which is manifestly impossible. Smoke once formed is not inflammable, and the term "smoke burning" is absurd. It requires 150 cubic feet of air for the combustion of 1 pound, or 300,000 cubic feet for a ton of coal. If therefore an engine be running at the rate of 34 miles per hour and consuming 60 pounds of coal per mile, it would require 2,040 pounds for an hour's run, during which time 300,000 cubic feet of air must be supplied to the fire box. That immeasurably too little air is supplied through the grates and ordinary hollow stay bolts the long black clouds of smoke attest. The gas of a ton of soft coal requires from 100,000 to 130 000 cubic feet of air per hour for its combustion, and the balance of the 300,000 cubic feet for the coke or solid portions. If it is assumed that a sufficient supply of air for the combustion of the coke will enter through the grates, we have still to supply by other means—hollow stay bolts or thimbles—the 130,000 cubic feet above the fire. It is stated that air under the influence of the exhaust will flow at the rate of 9,000 feet per minute, and the amount of air which would pass through an opening of one inch area under these conditions in one hour would be about 3,750 cubic feet.

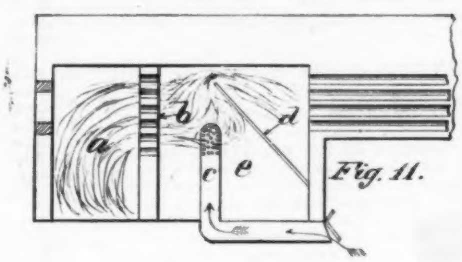


Fig. 11.

The area necessary then in the hollow stay bolts or thimbles would be $\frac{130000}{3750} = 34·6$, or say 35 square inches. The objections to hollow stay bolts or thimbles if supplied with this area of opening is that, while it allows of sufficient air in the bulk, it supplies too much air at times when the escape of gas is not sufficient to require this amount, and the economy of the consumption of fuel is injured by an oversupply at such times. It would therefore appear that a semi-regulating apparatus like Clark's steam jet would be preferable, as the supply of air would be in proportion to the amount of steam escaping from the nipples in the gas-pipe arrangement (see Figs. 6 and 7). If this device is used, the area of the openings would be much less, as the velocity of the inflowing air would be greater.

In practice it was found that eight 2 inch openings supplied with Clark's steam jet was equivalent to 40 square inches of opening through hollow stay bolts, with the exhaust alone drawing in the air. It would therefore seem that the secret of smoke prevention accomplished as far as is practicable consists in allowing a sufficient supply of air, as finely divided into streamlets as possible, *at the surface of the fire*.

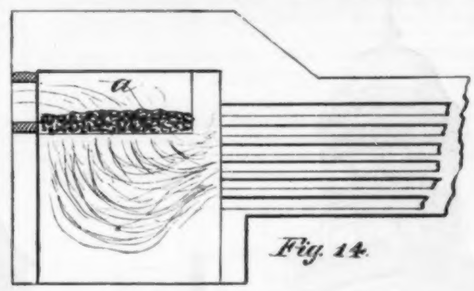


Fig. 14.

The value of the brick arch in the fire box is frequently questioned, and as it was at first used, it was an expensive device. It consisted of an arch built of fire brick, abutting against the side sheets. Owing to the lightness of the brick they soon burned out, and the abutment of the arch on the side sheets frequently caused them to leak; but when the arch is laid on pipe, as shown in Fig. 4, these objections disappear.

The value of a brick arch and its superiority over a water table consists of the facts that it supplies a means of igniting the gases, as the brick are highly heated from the fire when it consists of red coals, and gives out this heat to the gases when fresh coal is fired. The necessity of keeping up the temperature of the gases has been referred to, and this the brick arch does. Its position in the fire box necessitates the gases passing close to it; thus facilitates their ignition, as well as by changing the "run" of the gases, which is beneficial in assisting in mixing the air with the gases. The use of the extension smoke arch assists the brick arch, simply because it allows of using larger exhaust nozzles (because no cone is necessary in the stack), which decreases the velocity of the gases out of the fire box, thus allowing more *time* for their mixture on the fire box.

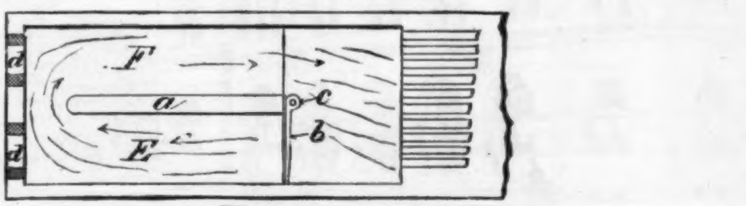


Fig. 12.

The water table is alone beneficial in changing the "run" of the gases to the flues, and assists in no way in heating the gases from fresh coal; on the contrary, it cools them and acts detrimentally, as the table is filled with water and acts as a conveyer or vehicle for transferring the heat from the gases to the water on the table, as it is necessarily a far better conductor than fire brick.

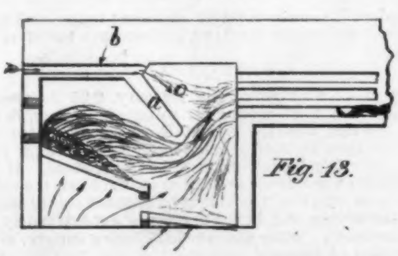


Fig. 13.

In conclusion, then, the best device for preventing smoke is a steam jet to force air into the fire box at the surface of the fire, regulated by throttling the globe valve supplying steam to the nipples, as far as practical, in connection with the brick arch, as shown in Fig. 4, and the extension smoke arch, or any device which does away with the cone in the stack and allows of larger nozzles. On the part of the fireman it is necessary to have wet coal fired in pieces no larger than a man's fist; a thin fire to allow of the air passing freely through it; a perforated fire door with a damper so that the supply of air can be increased when green coal is heavily fired; and a free use of the blower when an engine is going into stations shut off or standing still, as the effects of an admixture of steam with the smoke greatly assists in dissipating it.

SPERMACETI is being superseded for many uses by paraffine, and refiners are not now so anxious to take it out of the oil; but there is still a good demand for it from Sweden, where it is largely used in match making, a business lately very active.

THE GENERATION OF STEAM AND THE THERMODYNAMIC PROBLEMS INVOLVED.*

By W. ANDERSON, C.E.

THE lecturer commenced by remarking that the source of our fuel supply was derived from the rays of the sun acting upon the earth ages ago. He pointed out that those rays were of complex structure, intimately bound together and yet capable of being separated and analyzed. He remarked that it required over 1000 H. P. to separate one ton of carbon from the atmosphere in twelve hours; but that in consequence of the enormous area of leaf surface in which the decomposition took place, the action was silent and imperceptible. As soon as a law of definite chemical combination had been established, chemists began to suspect that the changes of temperature observed in chemical reactions were also of a definite kind, and that they were as much the property of matter as chemical atomic weights.

In the last century Lavoisier and Laplace, and after them, down to the present time, Dulong, Despretz, Favre, and Silbermann, Andrews, Berthelot, Thomsen, and others, had devoted much time and labor to the experimental determination of the heat of combustion and the laws which governed its development. Messrs. Favre and Silbermann in particular, between the years 1845 and 1852, had carried out a splendid series of experiments, by means of a calorimeter, which was illustrated by a diagram. The apparatus consisted of a gilt copper receiver, in which the substances tested were burnt by a jet of gas. This receiver was immersed in another vessel containing water, which again was protected by another vessel lined with swansdown. Thermometers of great delicacy were employed to determine the temperatures, and the whole of the apparatus used for generating the gases and for collecting the products of combustion was constructed with the utmost ingenuity and skill. Messrs. Favre and Silbermann adopted the plan of ascertaining the weight of the substances consumed, by calculations from the weight of the products of combustion.

By this means they were enabled to deal with larger quantities, and several errors incidental to the opposite process were eliminated. A table was given showing the calorific value and the chemical composition of such substances as commonly formed the constituents of fuel. The thermo-chemical laws relating to combustion and decomposition were then stated, and the general formula for calculating the thermic value of any kind of fuel whose analysis was known, was explained. It was pointed out that energy existed on the earth in a form which was often unsuitable for the wants of man. For example, the water flowing down the Alps was competent to furnish the power necessary for boring through those mountains; but it was not in a form which could be used directly. The kinetic energy of the water had first to be transformed into the potential energy of compressed air, and in that form it became available for miners. In the same way the energy of combustion could not be applied directly to the wants of man. It had first to be converted into the form of steam or air at high pressure and temperature, and then, by means of suitable heat engines, it could be used in the manner with which all are familiar. It was probably to this circumstance that the tardy development of the steam engine was due, for its history dated back only some two hundred years—a very small proportion of the time during which the human race had existed.

A steam boiler was in reality a species of heat engine, and its action should be investigated upon the same principles, and consequently the doctrines of Carnot were applied. According to these, the efficiency of a boiler depended entirely upon the range of temperature through which the heated gases acted, and, by means of an illustration derived from an application of water power, it was demonstrated that the proper way to increase the efficiency of a boiler was to raise the temperature of the furnace to the utmost degree possible, and to lower the temperature of the smoke to the lowest point practicable. Particular instances were then taken in which it was shown that 1 lb. of carbon would be capable of evaporating 14·87 lb. of water from and at 212°. The case of the prize engine of the Cardiff show of the Royal Agricultural Society in 1872 was described in detail, and it was demonstrated that the maximum amount of work which could be expected from its boiler was equivalent to the evaporation of 13·27 lb. of water, the actual evaporation having been 11·83 lb., showing a duty of 89 per cent.

In pursuance of the idea of treating a boiler as a heat engine, an indicator diagram was exhibited and explained, and the laws of Carnot were stated in detail and discussed. The terms of Carnot's formula were then examined separately—first in relation to the temperature of the furnace, the process of combustion was explained, and it was shown that the temperature of the furnace depended upon the supply of air. A minimum supply would give the highest temperature, but it was found necessary to add an excess in order to make combustion perfect. It was pointed out that the limit to high temperature in a furnace was the imperfection of the material out of which boilers were constructed. It was shown from the fact that steel was capable of being melted in boiler furnaces, that temperatures so high as that were not injurious; but that, when the melting point of steel was greatly exceeded, the boiler plates began to suffer severely.

Next, the temperature of the chimney end of the boiler was examined. It was stated that by the adoption of feed-water heaters and by the use of forced draught, not for the purpose of augmenting the steam production, irrespective of economy, but with a view to promoting economy, the temperature of the smoke could be lowered to about 100° above that of the feed water. The loss of 11 per cent. in the Cardiff boiler was then looked into, from which it appeared that it arose partly from radiation and convection from the body of the boiler, partly from imperfect combustion, which always prevailed more or less, and partly from losses incidental to the transfer of heat from substances less dense to others more dense, and *vice versa*. It was stated that this loss was common to all energy propagated by undulatory motion such as light, heat, or sound.

The law of conduction through plates was then explained, and it was pointed out that even joints in a bar of uniform material interposed a certain amount of resistance, and the fact was illustrated by an experiment. The loss was much greater when there was a joint between dissimilar materials, such as between the gases of the furnace and the boiler plate, and between the boiler plate and the water.

At first sight it would appear a matter of common sense that a boiler which contained its own furnace must be a

* Abstract of lecture delivered before the Institution of Civil Engineers, Dec. 6, 1883.

better generator than one with an external furnace formed of brickwork; but brickwork was an extremely bad conductor of heat, while it was a very good radiator, absorbing heat from the gases and returning them by adiation to the boiler surfaces. This action was strongly pronounced in the case of the reverberatory furnace, and in the brick arches now commonly introduced into the fire boxes of locomotives. The gases forming the products of combustion were very bad absorbers and very bad radiators of heat. Pure dry air and nitrogen were absolutely incapable of absorbing or radiating heat. They were not in the least affected by the passage through them of the most intense heat rays. Carbonic acid was a somewhat better radiator, while the vapor of water was a good absorber, and therefore a good radiator. It was then demonstrated that the products of combustion consisted mainly of air and nitrogen, and consequently, taken as a whole, the products of combustion were bad radiators.

Little or no economical advantage was derived from making the combustion in a boiler perfect, because the colder luminous flame was a good radiator, on account of the white-hot particles of carbon it contained, while the hotter and non luminous flame was a bad radiator, and carried a great deal of heat into the chimney. This circumstance was illustrated by an experiment, by which it was proved that an intensely hot non-luminous Bunsen flame had very little more effect upon an air thermometer than a smoky-luminous flame burning the same quantity of gas, but that the moment a spiral wire was hung in the Bunsen flame, it commenced to glow, and the radiation from the wire immediately had a powerful effect upon the thermometer. It was probably owing to this circumstance that the backwardness

of the owners of steam boilers to prevent smoke was to be attributed. Had considerable advantage been obtained by the suppression of smoke, Acts of Parliament would not have been necessary for the purpose.

A different class of boiler was required for consuming flaming fuel, as contrasted with such fuel as anthracite and coke, burning with very little flame. In the latter case, tubular boilers were preferable; but unless the combustion was perfect before the gases reached the small tubes, the gases cooled down so considerably that the flame was frequently extinguished. This fact was illustrated by an experiment, which showed that when pieces of half-inch gas pipe of various lengths were placed over an ordinary gas flame, the shorter tubes allowed the flame to pass through, while the longer ones extinguished it, and the gas could be relighted at their upper ends. Water being completely adiathermanous, and a very bad conductor, could not be heated by direct radiation or conduction. The process of heating by convection was explained in detail, and a comparison was instituted between the heat transmitted from the hot gases in the furnace of a boiler to the water, with the reverse effect of warming by the transfer of heat from hot water pipes to the air of a room. The two being reverse operations, agreed very closely together in accordance with the theory of exchanges.

The proper heating surface to be allowed in a boiler to effect a given amount of evaporation was then dwelt upon. The mode of calculating the sectional area of tubes and flues was given, the heat of the chimneys and their area was considered and finally the thermodynamic theories relating to the formation of steam were investigated. It was stated that, of necessity, the molecules of steam which became emancipated from the water through the energy of heat carried with them particles of water, and that these particles constituted priming, the amount of which depended upon the velocity with which the steam escaped from the water. A table was exhibited of a large variety of boilers ranged in order of the velocity and disengagement of steam from the water surface; and from this it appeared that those in which the velocity was highest were also those most subject to priming. The doctrine of the viscosity of liquids and gases was next dealt with, and applied to account for the manner in which particles of water and of very minute solid impurities were carried over from the water of the boiler into the steam.

The same theory was adduced to show that from the slowness with which smoke fell in the atmosphere, it must be composed of exceedingly small particles, and that they were not very numerous compared with the volume of the gases with which they were associated. It further went to show how it was that complete combustion did not produce any marked economy, because the absence of the white-hot particles of carbon from the gases caused a loss of radiating power. It was thought that no great improvement was to be expected in the economy of boilers, for the limit had been already almost reached. The honor of having first pointed out the true principles on which the duty of boilers should be estimated, namely, by comparing the work actually done with the potential energy of the fuel used, was due to the late Professor Rankine.

The lecturer concluded by a tribute of respect and admiration to the late Sir William Siemens, whose name was closely associated with the subject of his lecture. At the time of his death, Sir William Siemens was engaged in perfecting a pyrometer, intended to indicate accurately temperatures above those of melting steel. In addition, therefore, to the many causes of regret at his lamented decease, was to be added this, that the production of a trustworthy pyrometer would be indefinitely postponed. The impulse which Sir William Siemens had given to the study and elucidation of thermodynamics would not cease with his life, but this and succeeding generations would long profit by his example and his labors.—*The Engineer.*

COMPUTING THE HEATING SURFACE OF HOT BLAST STOVES.

FURNACE men in France and Germany have been for some time quite eagerly discussing hot blast stoves, their advantages, their drawbacks, and the best method of overcoming the latter. The leading journals of the Continent, *Stahl und Eisen*, *Le Génie Civil*, *Zeitschrift des Vereins Deutscher Ingenieure*, and others, have printed exhaustive articles in rapid succession, and a good many suggestions of value have been brought out. Among the most interesting contributions is an attempt by Herr Steffen to compute the heating surface required. We (the *Engineering and Mining Journal* says) may briefly run over his figures, as reviewed by Herr Fritz W. Luermann, a metallurgist whose name is thoroughly known in this country.

Assuming that it is desired to ascertain the heating surface of two blast furnaces, using each 75 tons of coke, or 150 tons together, deducting 15 per cent. for ash and moisture, it will be necessary to consume 92·39 kilogs. of carbon during every minute of the twenty-three hours actual blowing time. Steffen assumes that it will require only 4·3 cubic meters of gas per kilog. of carbon, a quantity which Luermann considers too low, as it would only convert the carbon into carbonic oxide. It should not, however, be confounded with the estimate made in computing the blowing engine capacity, usually placed by German engineers at 5·2 to 6·33 cubic meters. Taking the charge to be 1.000 kilogs. of coke, containing 850 kilogs. of carbon, 2,000 kilogs. of ore, and 250 kilogs. of fluxes, yielding 1,097·46 kilogs. of pig, Steffen estimates that 4,266·15 kilogs. of blast would yield 6,054·12 kilogs. of gas per 1.000 kilogs. of coke, or, 3,890 and 5,516 kilogs. respectively per 1.000 kilogs. of pig. If this quantity of blast were heated to 800° Celsius, it would carry into the furnace 744 calories per kilogramme of pig iron. In this theoretical case, Steffen calculates the heat required per kilogramme of iron at 3.953 calories, of which 3 209 must be furnished by the combustion of carbon. In reality, the 850 kilogs of carbon consumed per 1,097·45 kilogs. of pig iron produce 6,254 calories per kilogramme of pig, so that only 51 per cent. of the heat produced in the blast furnace is actually used in the manufacture of pig; and deducting losses, 5·097 kilogs. of gas per kilogramme of pig iron produced are available for other purposes, or, at the rate of production assumed, 607·56 kilogs. of gas, containing by calculation 22·5 per cent. of carbonic oxide and 0·5 per cent. of hydrogen, capable of yielding per kilogramme 715 calories, or 434,405 calories per minute. Luermann assumes that the 360 horse power blowing engine would require 1·5 kilogs. of coal per hour per horse power, or 12,420 kilogs. per run of twenty-three hours; and that the hoists, pumps, etc., would want 2,376 kilogs. more—a total of 14,796 kilogs. or 10·65 kilogs per minute. Taking the value of 1 kilog. of boiler coal at 7,500 calories, 1 kilog. would be equal to 10·49 kilogs. of gas, so the quantity of gas necessary for the boilers would be per minute 111·72 kilogs., leaving 495·84 kilogs. of gas for the hot blast stoves, or 354,525 calories per minute. Steffen estimates the loss of heat in the stoves by radiation and by the temperature of the escaping gas at 40 per cent., so that 212,714 calories would be available per minute. He states that practical experience has shown that it is not advisable to go in cooling beyond 1° Celsius per minute. Assuming the quantity W of blast delivered into the furnace at a temperature of 12° Celsius, the temperature to which it is to be heated T, the surface to be heated by the gas at 1·26 square meters per cubic meter of blast, the specific heat at 0·239, we have the formula:

$$1{\cdot}26 \times 0{\cdot}239 \times W \times (T-12) = X \text{ cal.}$$

The product X calories must be equivalent to the cooling of the mass of firebrick in the stove, and we have therefore the formula:

$$G \times 0{\cdot}25 \times t = X,$$

in which G is the weight of the masonry, 0·25 its specific heat, and t the rate of cooling per minute in degrees, in this case 1°. From this the weight G can be calculated, and by calling the weight of a cubic meter of brickwork 1,900 kilogs., its cubical contents may be ascertained. If the stoves work on gas twice as long as on the blast, the thickness of brick which will cool may be assumed at 0·10 meter, so that the surface will be twenty times approximately the cubical contents. Thus the needed heating surface, given consumption of fuel and production of pig per diem, may be roughly ascertained.

THE NEW POST OFFICE, MINNEAPOLIS.

WE give above an engraving of this new public building, for which we are indebted to the *American Architect*. The exterior appearance of the structure is indicative of utilitarian purposes; at the same time it has an air of elegance coupled with solidity, and the general effect is very satisfactory.

SORGHUM sugar, said to be of good quality and flavor, has been made this year for the first time in the vicinity of Phœnix, Arizona.

A WATER PYROMETER.

M. AMAGAT has contributed to the *Comptes Rendus* a "Note" on pyrometers, in which he refers to the classical experiments of M. St. Claire Deville upon dissociation. In the course of these researches, it was observed that if in a thin metallic tube, made exceedingly hot, a current of water is passed, this water will only be heated a few degrees, even with a moderate rate of flow. The fact furnished M. Amagat with his ideas for a pyrometer, in which the heating of water under these conditions should be made to give an indication of the high temperatures; and the idea has been embodied in an apparatus which has shown excellent results. A similar appliance has been constructed by M. De Saintignon, who uses a brass tube bent upon itself in the form of a long loop. A current of water traverses this tube, passing a thermometer at its entry, and again at its exit from the furnace. From the readings of these thermometers the temperature of the furnace is calculated. Reduced to this extreme simplicity, the apparatus is incapable, according to M. Amagat, of giving very regular results; because it is evident that the heating effect takes place not only in the curved portion of the loop, which is actually in the furnace, but also in the straight portions of the tube embedded in the furnace wall. In order to localize the action, M. Amagat has used, in place of a simple bend of the pipe, a spiral of sufficient length to produce, by itself, the principal share of heating effect. In the last examples of the apparatus that have been constructed, the water—after having communicated its temperature to the exit thermometer—traverses a long and narrow jacket enveloping the straight portions of the tube, the heating of which by other means consequently becomes insignificant, and may be neglected. The action of the fire being thus localized in the spiral, the instrument will work with perfect regularity, so long as the water in the supply-tank is maintained at a constant level or head. The indications of the instrument are almost instantaneous; the smallest variations of the heat of the furnace being immediately indicated. It may be added that, instead of exposing the metallic pipe directly to the intense heat of the furnace, it is generally preferable to inclose it in a refractory casing. Apparatus thus constructed has worked for many months in M. Amagat's laboratory; measuring temperatures up to 1200° C. with a regularity often greater than that of the air pyrometers exposed to the same heat. They are regulated so that for a temperature of 1000° in the furnace the water rises 10° C.

DUFOUR'S NEW REGISTERING BAROMETER.

THE pressure that the atmosphere exerts upon us varies not only from one place to another, but likewise in the same place. These variations are constantly occurring, sometimes within very short periods, and the barometer notifies us of them. Every one knows how important are the indications of this instrument for forecasting the weather. As it is impossible, even for the most assiduous observer, to constantly note the variations of this instrument, registering apparatus have been constructed which faithfully inscribe them, and which consequently show all the fluctuations of the atmospheric pressure.

This journal has already given a description of several of these instruments, but we believe, however, that it will be of interest to our readers if we describe one that is both simple and accurate that we have been using for several years in the laboratory of physics of the Faculty of Sciences of Lausanne (Switzerland). The simplicity of this apparatus is such that it is only necessary to glance at the accompanying figure to understand its principle. This barometer is a mercurial one, such being always more accurate than aneroid apparatus. It is formed of a glass tube, A, B, C, D, E, F, bent at right angles four times. This tube is closed at A and open at F. The branch, E F, carries a cock, R. The length of the part, C D, is nearly equal to the mean barometric height of the location of the observatory. The branches, B C and D E, are equal, and may have any length whatever—this depending upon the sensitiveness that it is desired that the instrument shall have; but lengths of from 15 to 20 centimeters answer perfectly well. The apparatus is filled with mercury, like an ordinary barometer, and is then placed in a vertical position and fixed in a collar that carries an axis, O, which passes above the center of gravity, so that the instrument can oscillate around it. The mercurial column rises in the two branches, A B and E F, up to N and N', for example, and fills all that part of the tube comprised between these two levels.

When the atmospheric pressure increases, the mercury rises in the branch A B, and falls in E F, and the result is

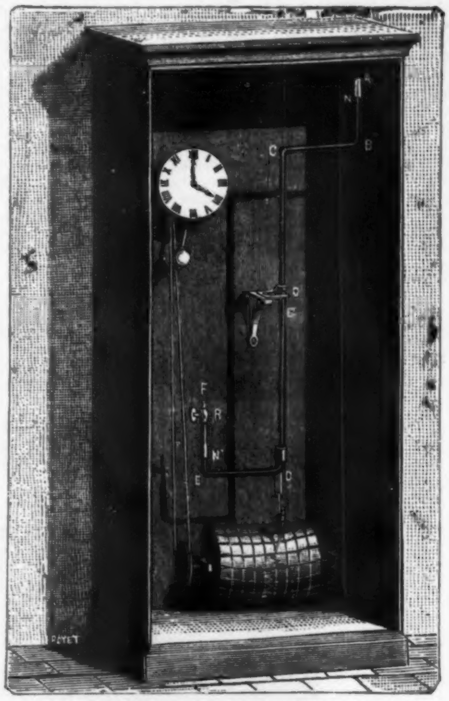


FIG. 1.—DUFOUR'S NEW REGISTERING BAROMETER.

that the weight of the apparatus increases to the left and diminishes to the right, and the tube inclines. If the pressure diminishes, the contrary occurs and the instrument inclines in the opposite direction.

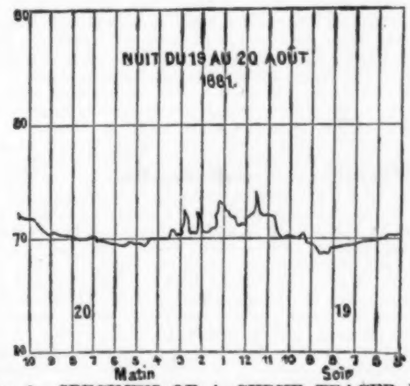


FIG. 2.—SPECIMEN OF A CURVE TRACED BY DUFOUR'S BAROMETER.

Every variation in pressure is shown, then, by a motion of the barometer tube, which oscillates around the point, O; and with every pressure there corresponds a definite position of the tube. In order to register such movements it suffices to fix a pen at the extremity, D, of the tube, for example, and this will trace a continuous line upon a cylinder revolving regularly around a horizontal axis.

The sensitiveness of the instrument depends evidently upon the length of the horizontal branches, B C and D E, and upon the distance from the center of gravity, G, to the axis of rotation, O. The barometer tube is a lever of the first class, and for this reason we have styled this apparatus a *lever barometer*.

The accompanying figure gives a general view of the instrument. The barometer tube will be seen to be held by a brass collar which carries two knives whose edges constitute the rotary axis of the system. The cylinder is carried along by a clock work movement actuated by weights or spring, and running for eight days. An endless cord connec s a pulley fixed upon a barrel (if it is a spring clock), with a pulley of proper dimensions keyed to the rotary axis of the cylinder, thus making the motion continuous and regular. The cylinder is covered with a sheet of divided paper whose horizontal lines indicate the hours, and whose vertical ones give the barometric heights. These lines are not equidistant, for the angular movement of the tube is not proportional for all the heights in the variations of pressure. But this defect is of no great consequence, since each instrument may be graduated once for all, and in a relatively short time. The cock, R, serves for this purpose, and the operation is as follows.

The barometer tube is inclined until the style is wholly to the left of the cylinder. The cock is then closed, and the apparatus being left to itself assumes, after a few oscillations, a fixed position. The difference of level that exists between the two extremities of the column of mercury is then measured by any process whatever (with a cathetometer, for example), and such difference measures in millimeters the pressure that the air is submitted to which is confined between the cock and the surface of mercury in the branch, E F. At the same time, the position of the style upon the cylinder is noted. The cock being open, the style will occupy the same position upon the cylinder every time the external pressure is equal to the figure found in this experiment. Upon repeating this measurement for other points, we obtain all that is necessary for dividing the sheet for observations, and from the original thus obtained as many sheets as may be desired may be reproduced by any process whatever.

This process of graduation possesses many advantages over the process by comparison usually employed, and it may be applied for all pressures, and the graduation of an instrument may be effected in a few hours by the constructor for any station whatever.

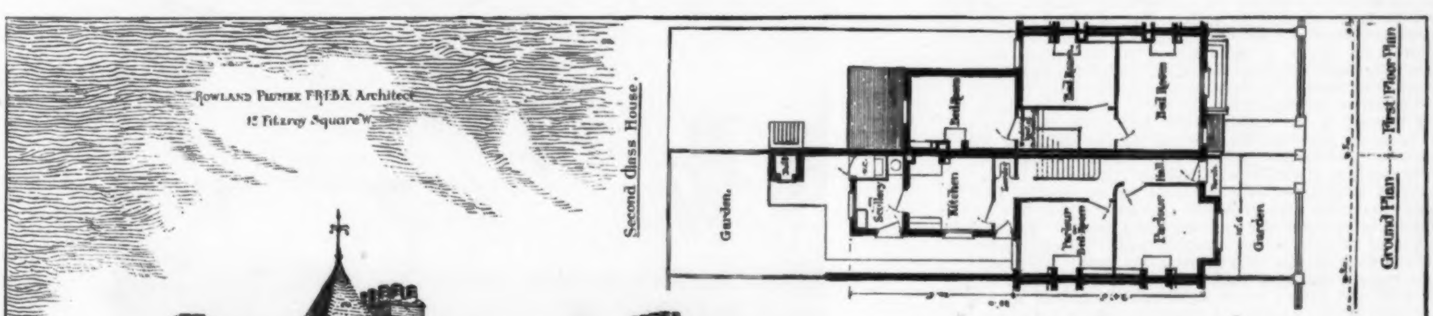
The amplification of an apparatus depends upon the length of the horizontal arms and upon the position of the suspension knife; and, as this latter may be varied at will, it is always easy to give the instrument any amplification that may be desired. As for sensitiveness, that is to say, the property possessed by the instrument of at once indicating the slightest and most rapid variations of atmospheric pressure, observation shows that the lever barometer leaves nothing to be desired in this respect, as we may assure ourselves by examining the tracing in Fig. 2 given by the instrument during a stormy day, when the amplification of the instrument was 4 millimeters per millimeter. Direct observations have permitted us to ascertain that the instrument follows variations in barometric pressure without any delay.

The ease with which this instrument may be anywhere constructed, with but little expense, causes us to hope that it may prove of some utility to meteorologists, and that some reader of this journal may be tempted to construct one, either as a registering apparatus or simply as an amplifying barometer.—*H. Dufour, in La Nature.*

ARTISANS' DWELLINGS, HORNSEY.

WE give a plate of artisans' dwellings which are at present being built at Hornsey.

They are built on plots 15 feet 6 inches by 80 feet in depth, and differ from the first-class merely in having one bedroom less and one water-closet merely on the ground floor. The rental is about 10s. per week. Mr. Rowland Plumbe, F.R.I.B.A., of 13 Fitzroy Square, W., is the architect.—*Building and Engineering Times.*



·Artizans', Labourers' & General Dwellings Estate at Hornsey· ·Terrace of Second Class Houses·

TELPHERAGE.

UNDER the designation of "telpherage," Prof. Fleeming Jenkin, in conjunction with Profs. Ayrton and Perry, has devised a system by which the transmission of vehicles by electricity to a distance, independently of any control exercised from the vehicle, is effected. The new system, although it has been tried experimentally in a thoroughly practical shape, and the details of which have been covered by a large number of patents, has not yet been brought to that stage of development which the inventors consider sufficient to justify the scheme being brought prominently to public notice, it being wisely considered advisable to postpone the introduction of the system until every little point of detail has been carefully and thoroughly worked out.

Through the kindness of Prof. Ayrton we have recently had an opportunity of inspecting the works of the "Telpherage Company, Limited," at Weston, near Hitchin, where experiments are being conducted on a large scale, with the object (as before stated) of thoroughly working out all necessary details.

In his inaugural lecture at the University of Edinburgh, Prof. Fleeming Jenkin referred to the new system as follows:

"'The transmission of vehicles by electricity to a distance, independently of any control exercised from the vehicle, I will call Telpherage.' These words are quoted from my first patent relating to this subject. The word should, by the ordinary rules of derivation, be Telphorage, but as this word sounds badly to my ear, I ventured to adopt such a modified form as constant usage in England for a few centuries might have produced, and I was the more ready to trust to my ear in the matter, because the word Telpher relieves us from the confusion which might arise between Telephore and Telephone when written.

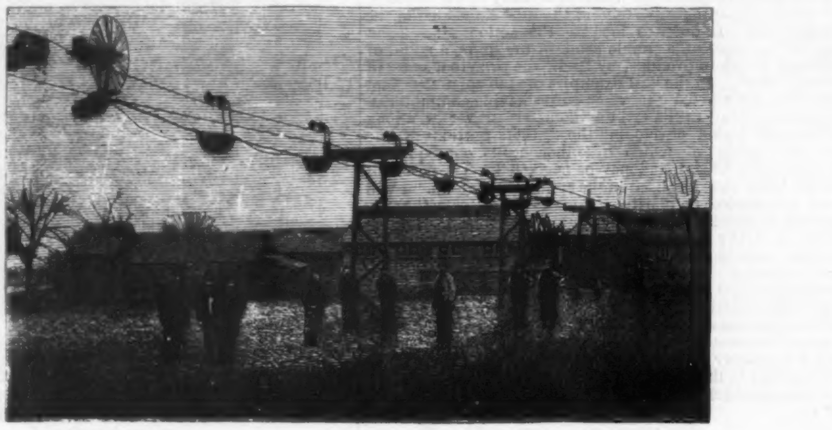
"I have been encouraged to choose Telpherage as the subject of my address, by the fact that a public exhibition of a Telpher line, with trains running on it, will be made this afternoon for the first time.

"You are, of course, all aware that electrical railways have been run, and are running with success, in several places. Their introduction has been chiefly due to the energy and invention of Messrs. Siemens. I do not doubt of their success and great extension in the future—but when considering the earliest examples of these railways in the spring of last year, it occurred to me that in simply adapting electric motors to the old form of railway and rolling stock, inventors had not gone far enough back. George Stephenson said that the railway and locomotive were two parts of one machine, and the inference seemed to follow, that when electric motors were to be employed, a new form of road and a new type of train would be desirable.

"When using steam we can produce the power most economically in large engines, and we can control the power most effectually and most cheaply when so produced. A separate steam-engine to each carriage, with its own stoker and driver, could not compete with the large locomotive and heavy train; but these imply a strong and costly road and permanent way. No mechanical method of distributing power, so as to pull trains along at a distance from a stationary engine, has been successful on our railways, but now that electricity has given us new and unrivaled means for the distribution of power, the problem requires reconsideration.

"With the help of an electric current as the transmitter of power, we can draw off, as it were, one, two, or three horse-power from a hundred different points of a conductor many miles long, with as much ease as we can obtain 100 or 200 horse-power at any one point. We can cut off the power from any single motor by the mere break of contact between two pieces of metal; we can restore the power by merely letting the two pieces of metal touch; we can make these changes by electro-magnets with the rapidity of thought, and we can deal as we please with each of one hundred motors without sensibly affecting the others. These considerations led me to conclude, in the first place, that when using electricity we might with advantage subdivide the weight to be carried, distributing the load among many light vehicles following each other in an almost continuous stream, instead of concentrating the load in heavy trains widely spaced, as in our actual railways. The change in the distribution of the load would allow us to adopt a cheap, light form of road. The wide distribution of weight entails many small trains in substitution for a single heavy train. These small trains could not be economically run if a separate driver were required for each. But, as I have already pointed out, electricity not only facilitates the distribution of power, but gives a ready means of controlling that power. Our light continuous stream of trains can therefore be worked automatically, or managed independently of any guard or driver accompanying the train—in other words, I could arrange a self-acting block preventing collisions. Next came the question, What would be the best form of substructure for the new mode of conveyance? Suspended rods or ropes, at a considerable height, appeared to me to have great advantages over any road on the level of the ground; the suspended rods also seemed superior to any stiff form of rail or girder supported at a height. The insulation of ropes with few supports would be easy; they could cross the country with no bridges or earthworks; they would remove the electrical conductor to a safe distance from men and cattle; cheap small rods, employed as so many light suspension bridges, would support in the aggregate a large weight. Moreover, I considered that a single rod or rail would present great advantages over any double rail system, provided any suitable means could be devised for driving a train along a single track. (Up to that time two conductors had invariably been used.) It also seemed desirable that the metal rod bearing the train should also convey the current driving it. Lines such as I contemplated would not impede cultivation nor interfere with fencing. Ground need not be purchased for their erection. Mere way-leaves would be sufficient, as in the case of telegraphs. My ideas had reached this point in the spring of 1882, and I had devised some means for carrying them into effect when I read the account of the electrical railway exhibited by Professors Ayrton and Perry. In connection with this railway they had contrived means for rendering the control of the vehicles independent of the action of the guard or driver, and this 'absolute block,' as they called their system, seemed to me all that was required to enable me at once to carry out my idea of a continuous stream of light, evenly-spaced trains with no drivers or guards. I saw, moreover, that the development of the system I had in view would be a severe tax on my time and energy, also that in Edinburgh I was not well placed for pushing such a scheme, and I had formed a high opinion of the value of of the assistance which Professors Ayrton and Perry could give in designs and inventions.

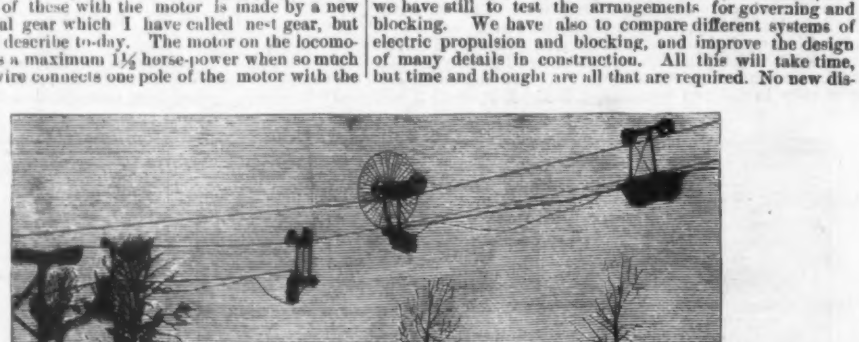
"Moved by these considerations, I wrote asking Prof. Ayrton to co-operate in the development of my scheme, and suggesting that he should join with me in taking out my first Telpher patent. It has been found more convenient to keep our several patents distinct, but my letter ultimately led to the formation of the Telpherage Company (Limited), in which Prof. Ayrton, Prof. Perry, and I have equal interests. This company owns all our inventions in respect of electric locomotion, and the line shown in action today has been erected by this company on the estate of the chairman—Mr. Marlborough R. Pryor, of Weston. Since the summer of last year, and more especially since the formation of the company this spring, much time and thought have been spent in elaborating details. We are still far from the end of our work, and it is highly probable what has been done will change rapidly by a natural process of evolution. Nevertheless, the actual line now working does in all its main features accurately reproduce my first conception, and the general principles I have just laid down will, I think, remain true, however great the change in details may be.



LOCOMOTIVE. SKIP. SKIP. SKIPS.

FIG. 1.—CROSS OVER PARALLEL TELPHER LINE.

"The line at Weston consists of a series of posts, 60 feet apart, with two lines of rods or ropes, supported by cross-heads on the posts. Each of these lines carries a train; one in fact is the up line, and the other the down line. Square steel rods, round steel rods, and steel wire ropes are all in course of trial. The round steel rod is my favorite road at present. The line is divided into electrical sections of 120 feet or two spans, and each section is insulated from its neighbor. The rod or rope is at the posts supported by cast iron saddles, curved in a vertical plane, so as to facilitate the passage of the wheels over the point of support. Each alternate section is insulated from the ground; all the insulated sections are in electrical connection with one another—so are all the uninsulated sections. The train is 120 feet long—the same length as that of a section. It consists of a series of seven buckets and a locomotive, evenly spaced with ash distance pieces—each bucket will convey, as a useful load, about $2\frac{1}{2}$ cwt., and the bucket or skip, as it has come to be called, weighs, with its load, about 3 cwt. The locomotive also weighs about 3 cwt. The skips hang below the line from one or from two V wheels, supported by arms which project out sideways so as to clear the supports at the posts; the motor or dynamo on the locomotive is also below the line. It is supported on two broad flat wheels, and is driven by two horizontal gripping wheels; the connection of these with the motor is made by a new kind of frictional gear which I have called nest gear, but which I cannot describe to-day. The motor on the locomotive will give as a maximum $1\frac{1}{2}$ horse-power when so much is needed. A wire connects one pole of the motor with the leading wheel of the train, and a second wire connects the other pole with the trailing wheel; the other wheels are insulated from each other. Thus the train, wherever it stands, bridges a gap separating the insulated from the uninsulated section. The insulated sections are supplied with electricity from a dynamo driven by a stationary engine, and the current passing from the insulated section to the uninsulated section through the motor drives the locomotive. The actual line is quite short, and can only show two trains, one on the up and one on the down line, but with sufficient power at the station any number of trains could be driven in a continuous stream on each line. The appearance is that of a line of buckets running along a single telegraph wire of large size. A block system is devised and partly made, but is not yet erected. It differs from the earlier proposals in having no working parts on the line. This system of propulsion is called by us the Cross Over Parallel Arc. Other systems of supplying the currents, devised both by Professors Ayrton and Perry and myself, will be tried on lines now being erected; but that just described gives good results.



HANGING BAG. LOCOMOTIVE. LOCOMOTIVE. SKIP.

FIG. 2.—CROSS OVER PARALLEL TELPHER LINE. TRAINS PASSING EACH OTHER.

The motors employed in the locomotives were invented by Messrs. Ayrton and Perry. They are believed to have the special advantage of giving a larger power for a given weight than any others. One weighing 96 lb. gave $1\frac{1}{2}$ H.P. in some tests lately made. One weighing 36 lb. gave 0·41 H.P.

"No scientific experiments have yet been made on the working of the line, and matters are not yet ripe for this, but we know that we can erect a cheap and simple permanent way, which will convey a useful load of say 15 cwt. on every alternate span of 120 feet. This corresponds to $18\frac{1}{2}$ tons per mile, which running at five miles per hour would convey $92\frac{1}{2}$ tons of goods per hour. Thus, if we work for 20 hours, the line will convey 1,850 tons of goods each way per diem, which seems a very fair performance for an inch rope. The arrangement of the line with only one rod instead of two rails diminishes friction very greatly. The carriages run as light as bicycles. The same peculiarity allows very sharp curves to be taken, but I am without experimental tests as yet of the limit in this respect. Further, we now know that we can insulate the line satisfactorily, even if very high potentials came to be employed. The grip of the locomotive is admirable and almost frictionless—the gear is silent, and runs very easily. It is suited for the highest speeds, and this is very necessary, as the motors may with advantage run at 2,000 revolutions per minute.

"The suspended rods are not suitable for high speeds. Centrifugal force would cause great strains on them, and the vehicles would be shot up into the air at the points of support. Very high speeds might be attained for light trains with a stiff road, but we are for the present less interested in this application of our ideas. A smaller type of line with $\frac{5}{8}$ rods and smaller spans is in course of construction. This will probably soon be extended for a mile or so, now that we have gained some experience on the few spans of this heavier line.

"At present we do not contemplate working lines extending more than five miles from a station, so that in a long continuous line we should require stations at intervals of 10 miles. A single station could work, either simultaneously or in succession, a large number of lines radiating from it in many directions.

"I cannot yet enter into questions of cost, and the company is hardly ready to undertake contracts, except perhaps for very simple cases. We have still to elaborate designs for sidings, for loading and marshaling the trains, and we have still to test the arrangements for governing and blocking. We have also to compare different systems of electric propulsion and blocking, and improve the design of many details in construction. All this will take time, but time and thought are all that are required. No new discovery is wanted; no unforeseen difficulty has been met with.

"I am almost afraid to speak of the probable uses to which Telpherage may be put. If I said all I thought, I should be told I was describing an electrical Utopia. The first and most obvious use of a Telpher line is that to which existing wire tramways are already put—namely, the conveyance of minerals or ore from mines, to canals, railways, or the sea. The suspended wire rope is specially suited for rocky, uneven ground, and very heavy gradients could be worked. The Telpher line has the following advantages over the present system: It can go round sharp curves, change the gradient as often as is desired, and be made of any length; any train can be stopped and shunted without stopping the others. If made with no working parts, as in the present example, the permanent way may be left idle for part of the year with no sensible deterioration.

"Mineral traffic of this kind is, however, in my opinion, only one small part of the work which these lines can do.

Where railways and canals do not exist, Telpher lines will provide the cheapest mode of inland conveyance for all goods, such as corn, coal, root crops, herrings, salt, bricks, hides, and so forth, which can be conveniently subdivided into parcels of one, two, or three hundred weight. In new colonies the lines will often be cheaper to make than roads, and will convey goods far more cheaply. In war they will give a ready means of sending supplies to the front. Moreover, wherever a Telpher line exists, power is thereby laid on, and this power may be used for other purposes than locomotion—a flexible wire attached to the line will serve to drive a one, two, or three horse engine, which may be used for any imaginable purpose, such as digging, mowing, thrashing, or sawing. It is true that in the transmission of the power more than half may be wasted; but the proportion wasted is diminishing yearly, monthly, almost daily, with the growth of our electrical knowledge; and when we remember that by stationary engines in London power can be produced at the rate of about one halfpenny per hour for each effective horse, we shall not be alarmed at the prospect of doubling this cost when the power is delivered on a rough hillside—especially when we remember that the engine receiving that horse power need weigh no more than 100 lb. Surely I am not too sanguine in expecting that great changes will be produced in agriculture by these new facilities for transport, coupled with the delivery of power at will from any point of the Telpher road. It must not be supposed that I look on the new Telpher lines as likely to compete with railways or injure their traffic. On the contrary, my feeling is that they will act as feeders of great value to the railways, extending into districts which could not support the cost even of the lightest railway. It is idle to endeavor to foretell the future of any new idea; but this much is certain—a novel mode of transport offering some exceptional advantages will be publicly shown on a practical scale to-day."

The three large illustrations which we give are from photographs of the experimental Telpher lines erected at the company's works at Weston.

The line shown by Figs. 1 and 2 consists of two steel conductors running parallel to each other, and supported at the ends of cross-beams fixed on the top of wooden supports. These steel conductors serve both for the conveyance of the electric current and also as rails on which run the electric locomotive and the skips drawn by the former. One conductor forms the "up" line, and the other the "down" line.

The skips are connected to the locomotive and to each other by long wooden draw-rods, so that a train of considerable length, distributed over several spans, can be formed. For the working of system it is necessary that the length of the train be not less than one span, though it may be extended beyond this to any extent required.

The line, as arranged at Weston, is adapted for working either on the "cross over parallel" or the "series" system. The principle of the first method is explained by Fig. 4.

In this Fig. f_1, f_2, f_3, represent some of the points of support of the conductors. Each span, both of the up and down line, is insulated from its neighbor in the manner shown in the above figures. But a very much simpler modification, which is now being tried, is shown in Fig. 6. The insulation of this simpler form is only good enough for the series system—to be presently described; but its three parts, A, B, and C, correspond with three very much more perfectly insulated and similarly situated parts of the existing post heads suitable for the cross over parallel system. In this Fig. A and B are cast steel supports, bolted down on a wooden block, which latter is itself bolted to the end of the cross-beams before referred to; on this block may be the end of the cross-beam itself. The upper surfaces of A and B are channeled to receive the conductors, W_1 and W_2. These conductors pass one on each side of the cast steel piece, C, and go through holes in the wooden block, being secured in the latter by nuts, as shown. The piece, C, is bolted on the wooden block in a position intermediate between A and B, but is insulated from the two latter. This piece serves as a continuation between the rods, W_1 and W_2, so that the wheels of the locomotive and skips can ride from W_1 to W_2 with regularity and smoothness.

In the "cross over parallel" system, shown by Fig. 4, the support, A (Fig. 6), would be electrically connected to the support corresponding to B, at the other end of the cross beam, while B (Fig. 6) would be electrically connected to the support corresponding to A, at the other end of the cross-beam.

Referring to Fig. 4, it will be seen that if one pole of the dynamo be connected with the left hand extremity of the conductor represented by the continuous line, the other pole being connected with the uninsulated line, shown dotted, then supposing the trains, M and N, to be in the positions shown, a portion of the electric current must pass through each train, and by actuating the locomotives in their circuit must put them in motion. The length of the train is very nearly equal to that of an electrical section of the line, and by a special device not yet made public there is a certainty that there is never any dead point. It must be obvious that the number of trains which can be running on each conductor is not limited to one only.

The "series" system of working, a photograph of which is shown in Fig. 3, will be understood from Fig. 5, which represents a single conductor. In this method the electrical breaks in the spans at g_1, g_2, g_3, etc., are kept normally closed by means of switches; these switches are opened automatically immediately a train bridges over them, so that the current is caused to pass through the train and thus keep it in motion; immediately that the train has passed over the break the switch of the latter is automatically closed again either mechanically or electrically, so that the continuity of the circuit is preserved. As in the "cross over parallel" system, several trains can be running at the same time on the line, and with this system no special contrivance is necessary to avoid a dead point, other than that the train must be longer than an electrical section, so that the box in front is always opened before the one in the rear is closed.

An advantage of the "series" system is, that only one conductor is required as against two in the "cross over parallel" arrangement; the necessity of having automatic switches, however, must to some extent counterbalance this advantage; but, as the two sections of a line are never required to be insulated from one another, except when they are joined by a motor on a train, the total effective resistance of which, including back electromotive force, can never exceed a few ohms, it follows that the insulation between A and B (Fig. 6) need not be nearly as perfect as in the cross over parallel system. Hence the cost of the contact boxes necessary with the series system will probably be more than counter balanced by the cheapness of the heads of posts possible with this system. It must also be pointed out, however, that by working the series system with a small current and high electromotive force, the waste of power may be made very small indeed. Experiments are being made with motors, producing each 1½ horse-power, working with 500 volts, and requiring a current of two or three amperes only. The use of such a high electromotive force, is, however, we think, objectionable, as considerable loss would result in damp weather, unless the insulation of the line were very good. But should there be found difficulty in obtaining this, it is possible in the series system to support the whole top of the post (Fig. 6) on a good insulator, which, only having to support the resultant downward thrust, may have high insulation combined with sufficient strength.

The working of the gearing between the electromotor and the driving wheels is effected by very ingenious arrangements, devised by the three patentees, by which the strain which, in ordinary gearing, is thrown on the rotating axles, as for instance when two wheels are geared together by belting, is entirely got rid of. One method by which the object is effected is shown by Fig. 7. A and B are two which are required to tightly gripe the carrying rod, r, between them. On the axles of A and B, two small wheels, a and b, are fixed; these wheels gear by friction with the small wheels, c and d—c being fixed on the axle, f, and d sliding loose on it but being prevented from turning by being on a square arbor. The wheel, d, is kept pressed to the left by a strong spiral spring, s, which presses against a collar, e, on the axle, f. It will thus be seen that a and b, and consequently A and B, are strongly pressed together against the carrying rod, r, without any frictional strain being brought to bear on the bearings in which the upper ends of the axles, h and j, turn.

The axle, f, or any of the other axles, being geared to the motor, the rotation of the latter will cause the whole frame in which the motor and the gearing is set to be advanced along the carrying rod, r. The frame itself rests on the carrying rod through the medium of grooved wheels.

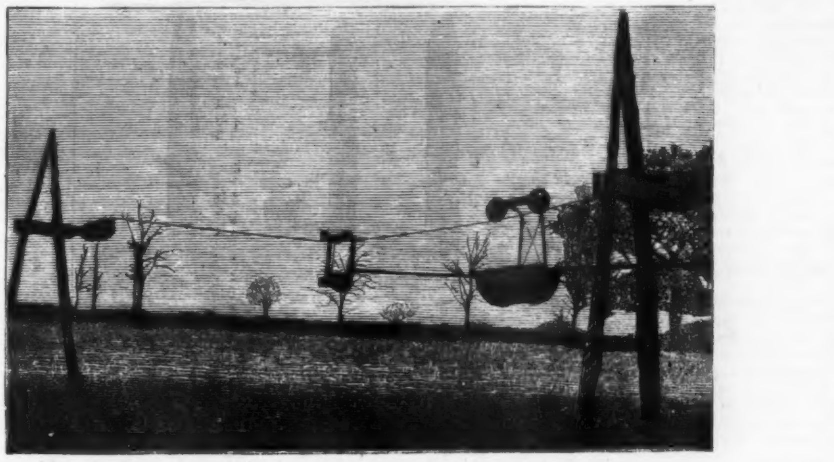
The motor being constructed to turn at a very high velocity does not work direct on to the axles, but in one of the locomotives used at Weston, the axle, f, has a large bicycle wheel fixed on it (see Figs. 1 and 2), and the motor turns this wheel through the medium of anti-frictional gearing, arranged very much on the same principle as the gearing shown by Fig. 7.

Another arrangement of gearing adopted in the small locomotive seen to the left in Fig. 2, is shown by Fig. 8. A is a crown wheel with a smooth inner rim, and B a smaller wheel with a smooth outer rim. Wheel B is set slightly eccentric to wheel A. Between the rims of the wheels are three small wheels, w_1, w_2, w_3; the latter is fixed on the axle of the electro-motor. w_1 and w_2 are set in two links hinged to a third link, K, which latter is kept pressed forward by a force applied in the direction of the arrow. By this means it is obvious that, owing to the eccentricity of the two wheels, A and B, the three wheels, w_1, w_2, and w_3, must all be in firm contact with the rims of A and B; so that w_3 when turned must also turn by friction both the wheels, A and B. It must be also obvious that although w_3 is in firm frictional contact with A and B, yet there is no strain whatever on its axle pivots. The wheel, B, is an idle one and runs freely on its own axle; A is geared through the medium of a long axle (seen in Fig. 2) to a set of gearing similar to that shown in Fig. 7. Another form of these frictional gearings is adopted in the small locomotive seen in Fig. 3. This is shown by Fig. 9. A is a wheel with a conical groove in it; this wheel is geared by means of its axle (seen in Fig. 3) to gearing similar to that seen in Fig. 7. a is the axle of the electro-motor; on this axle a cone, c, slides on a square arbor; this cone is kept pressed forward by means of a strong spiral spring. c_1 is a second idle cone placed in the position shown. By this arrangement it is obvious that while the axle, a, is firmly geared by friction to the wheel, A, yet there can be no frictional strain on the bearings of a.

To make "telpherage" possible, a light electro-motor of considerable power is necessary; this electro-motor Profs. Ayrton and Perry have succeeded in producing, as a motor constructed on their plan and weighing 96 lb. only, will give out 1½ horse-power at the rotating spindle.

The difficulty of preventing a train from running into a train ahead has been overcome by Prof. Ayrton and Perry's absolute block system, and also by their plan of "governing" the motors so that they run always at the same speed whatever work they have to do, that is to say, whether they are running up hill or down.

The train shown in Fig. 1 carries about 18 cwt., or nearly a ton, in addition to the weight of the locomotive and seven skips.—*Electrical Review.*



LOCOMOTIVE. SKIP.

FIG. 3.—SERIES TELPHER LINE.

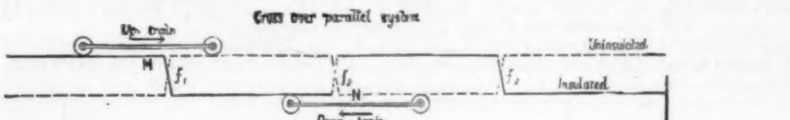


FIG. 4.

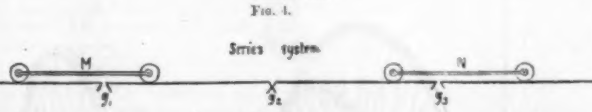


FIG. 5.

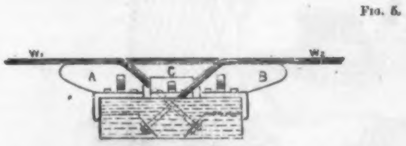


FIG. 6.—TOP OF POST FOR THE SERIES SYSTEM.

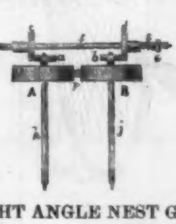


FIG. 7.—RIGHT ANGLE NEST GEARING.

FIG. 8.—MORTAR MILL NEST GEARING.

FIG. 9.—RIM GEARING.

THE COST OF ELECTRIC BATTERIES.

THE statements which have been recently made in the daily papers as to the effects produced by the use of primary batteries in lighting railway carriages have brought us many queries, not a few from persons who appear to imagine that the cost of lighting by that means is measured by the first cost of the battery and the lamps. Most schoolboys have nowadays learned the simple lesson that out of nothing, nothing comes; but judging by some of the paragraphs that we have seen in daily papers, it is perhaps excusable that not a few of our querists should imagine that something remarkably cheap has been discovered, and that they can have the electric light at a merely nominal cost. We have recently pointed out, not once merely, but several times, that an electric light obtained from any known battery is really expensive as compared with the same amount of illumination obtained from gas or other cheap source of light, and that there is no hope of reducing the expense until some one discovers a battery the decomposition of the elements of which will produce a substance or substances which shall be worth at least as much as the raw materials themselves. We have, from time to time, described cells or battery arrangements, patented and otherwise, the inventors of which thought they had made one step toward the desired goal; but at present, notwithstanding all the puffing, we are

unacquainted with any battery which, all things considered, is cheaper than the well-known combination of zinc and carbon excited by dilute sulphuric acid and bichromate of potash or nitric acid. For bells, telephones and telegraphs, electro metallurgy and medical purposes, other arrangements are more suitable; but in the case of electric lighting and electro-motors, a constant and ample supply of energy to the full capacity of the battery is required, and at present we have not found a cheaper metal to oxidize or consume than zinc. This is an old tale. It must be quite forty years since Staite took out a patent in which the commercial value of the residual products was mentioned, and latterly we have had several inventors taking up the old idea, without, however, demonstrating by actual receipts that they obtained any return worth mentioning for the zinc and sulphuric acid expended. Probably if primary batteries came to be used on a very large scale indeed, a sufficient quantity of residual products might be obtained to find a ready sale; but it is extremely doubtful whether more than a fraction of the prime cost would be recouped, unless the battery can be induced to manufacture some unknown and really valuable substance while giving out current. In one of the new batteries, which is, we believe, working very well on several railways, lighting carriages with lamps of from 5 to 10 candle-power, zinc and carbon form the two elements, and the battery is excited by a composition named "oxidone," the exact nature of which is kept secret until the patents are completed. The working cost of this battery is stated to be as low as one-eighth of a penny per hour for each 5-candle lamp, and a battery of 16 cells will supply 18 lamps, and can be charged for 40 hours—that is, the battery can be used for 10 hours on each of four days without needing to be recharged. Taking batteries as we know them in practice, such a result as that must be regarded as very good indeed; but if the cost has been arrived at by allowing for the sale of the residual products, it will at once be seen that the battery is not so cheap as a good steam-engine and dynamo, for when current is obtained by the oxidation of zinc the cost is about nine times greater than when a machine is used and the source of the energy is coal at about 20s. a ton. Mr. Sprague worked out this little sum for the benefit of all whom it concerns some years ago, and he found that taking the expense of the battery as only 4d. per pound of zinc the cost of a horse-power for 24 hours was 25s., whereas the same amount of energy could be obtained from a common steam-engine and coal at 20s. for 10·29d. Even if we suppose the residual products of any battery in which zinc is employed return 2d. for every pound consumed—and no one has supposed that possible among the most sanguine inventors—it will be seen that the common steam-engine has still the advantage as a motive power. Electrical machines have been considerably improved since Joule calculated that 75 lb. of zinc would be necessary for one to maintain a horse-power for twenty-four hours; but so have steam-engines, and therefore we are brought back to the simple datum that the oxidation of zinc can produce so much and no more energy, and that unless some one can be found to pay a high price for sulphate of zinc, there is no chance of any of the well-known cells in which it is consumed becoming a cheap source of electric light. It seems abundantly clear, from a number of experiments, that the most that can be expected from the best steam-engines and dynamos is 200 candles of incandescent lighting per horse-power, and as it is also tolerably apparent that two pounds of zinc are necessary to obtain the same quantity of energy, we have sixpence as compared with a farthing as the relative cost of the two sources of energy for electric lighting. It is not impossible that these figures are too favorable to the battery, for Mr. Sprague says that the cost of an equivolt of energy, by a common steam-engine, is only 0·00112 of a penny, while by a Daniell battery it is 0·0541. There is this to be said, however, that even if the cost of working a 20-candle lamp is as much as one halfpenny per hour, there are many persons who would prefer it to gas or any other illuminant; and if the new batteries can be made to produce a really useful substance as a residual, the trouble and attention they may entail will not stand in the way of their adoption. So far as we know, a 20-candle light cannot be maintained at a cost of one halfpenny per hour, even when the zinc and the acid can be purchased in quantities at the lowest price; but if a battery is in existence which will yield such results, it is a pity those who own it do not make it known, for it is certain they would have a very wide sale provided they could guarantee its performance. At the price named it would be too costly for lighting on the large scale; but there are very many persons who would go to the expense of fitting up the battery and the lamp, if they could have a light of twenty candles at a cost of a halfpenny an hour. Possibly before long some one may invent an iron or a lead battery, and then those who are so anxious to have the electric light will probably have an opportunity of gratifying their desires; as, indeed, they may now, if only they are prepared to pay for them. But so long as zinc is used there is small chance of primary batteries supplanting dynamos and steam-engines.—*Eng. Mechanic.*

AN EASILY-CONSTRUCTED MICROPHONE.

A CORRESPONDENT of *La Nature* gives the following description of a microphone which any person who has the materials at hand can easily construct for himself.

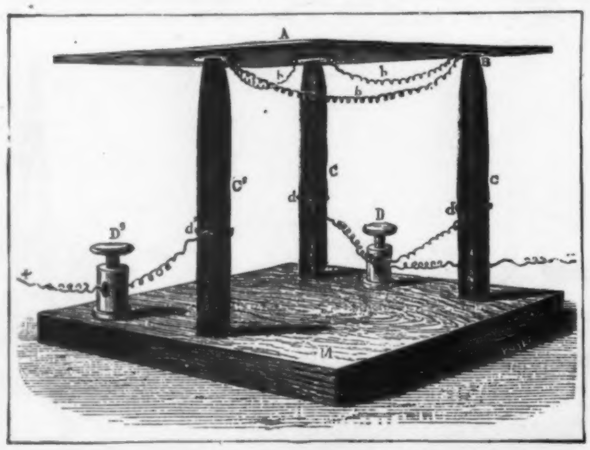
In this instrument, which is represented of actual size in the accompanying cut, the vibrating plate, A, consists simply of a visiting-card of medium thickness, cut square. Such a shape is much better than a round one, as the latter, although more elegant in appearance, does not give so good results. To this card there are affixed by means of sealing-wax three thin and light disks of carbon, BBB', of the kind used for the electric light. These three disks occupy symmetrically the three apices of an equilateral triangle, and are put in communication by means of copper wires, *bbb*. With this object in view, a small aperture is formed in each disk, and into this is fixed the extremity of a copper wire either by cement or friction. The copper may be advantageously replaced by platinum. Finally, the three wires are united.

The rest of the apparatus consists of a square wooden base, M, which supports three prismatic carbon rods, CCC', that exactly correspond to the three disks, BBB'. The two rods, CC, communicate by copper or platinum wires, *dd*, with the same terminal, D. The third rod, C', communicates alone with a second terminal, D'. The upper extremity of these carbon rods must be chisel-shaped, such a form having been found to give the best results, inasmuch as the contacts become fewer in this case. The rods are fixed to the wooden base by means of sealing-wax.

The theory of this microphone is very simple. The current enters, for example, through the terminal, D, follows the rod, C', and then the disk, B'. From the latter it passes through the wire, *b*, into the two disks, BB, to return to the terminal, D, in traversing the two rods, CC.

This little instrument will prove very sensitive to the voice and all noises, provided that the plate, A, be given a proper weight, one that is neither too heavy nor too light. If this be done, the voice of a person speaking in an ordinary tone may be distinctly heard at the end of the room that contains the microphone. The sounds of a piano are particularly well rendered by it. The apparatus must be placed upon a table at a distance of two or three meters in order to protect it from the jarring of the earth.

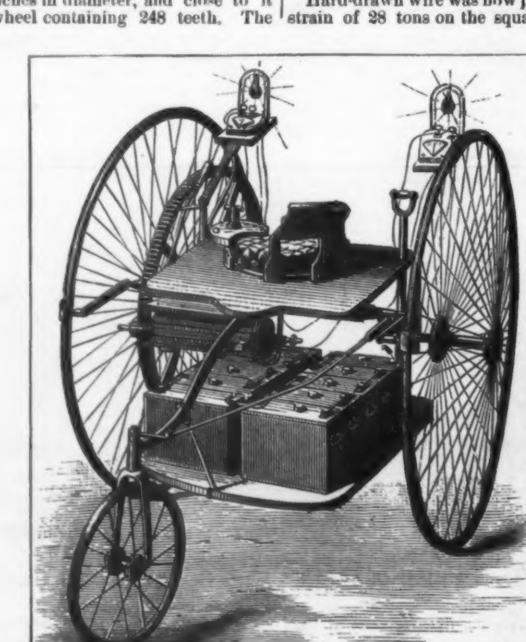
As for the pile necessary for actuating the instrument, one small Bunsen element or two or three Leclanche elements may be used. Apropos of the Leclanche pile, the author states that he uses a modification of it formed of a zinc and a carbon plate, both of them dipping into a saturated solution of bichromate of potash and hydrochlorate or sulphate of ammonia. The construction is very simple; it is the bichromate pile less the costly mechanism designed to remove the zinc from the action of the acid when the pile is at rest. This element does not wear away when the current is interrupted, as in the Leclanche pile. One obstacle at first rendered the use of this pile very difficult, and that was the fact that the ammoniacal salts rose along the carbons and attacked the communicating wires so that these broke and thus interrupted the electric current. But, thanks to Mr. Preaubert, it is now easy to overcome this difficulty. It is only necessary to dip the carbons into a bath of boiling paraffine, then allow the whole to cool, and afterward to scrape the carbon with a knife so as to free its surface of the paraffine. This latter material pene trates the pores of the carbon without notably changing its electric conductivity. The liquids are thus no longer able to rise through capillary attraction. Leclanche got around the difficulty by leaden armatures, but the means discovered by Mr. Preaubert are simpler. The electromotive force of this new element appears to be greater than that of a Leclanche of the same dimensions.



AN EASILY CONSTRUCTED MICROPHONE.

THE ELECTRIC TRICYCLE.

THE annexed engraving is an illustration of Ayrton and Perry's electric tricycle—an open fronted machine of ordinary pattern, with the treadles and driving gear removed. The driving-wheel is 44 inches in diameter, and close to it will be seen a large spur-wheel containing 248 teeth. The motor is slung from the seat platform, and the armature spindle carries a pinion of 12 teeth, gearing into the spur-wheel—the machine being thus speeded down 20 to 1. Taking 460 revolutions of the driving wheel to cover one mile, it will be found that the motor must make about 1,200 revolutions per minute to reach a speed of eight miles an hour The battery, composed sometimes of Faure cells, sometimes of Sellon-Volckmar, and at times of combinations of the two, is slung from the backbone and axle, and, when fully charged, contains a store of energy equal to about two horse-power-hours. The motor, which is rather too large, weighs 45 lb., and with the battery there is altogether a weight of 150 lb., sufficient to give a speed of six miles an hour. With an increased weight of accumulators a speed of eight miles has been maintained. The steering handle and brake are shown in their usual positions; but on either side of the rider brackets extend, each carrying a small four-candle incandescent lamp to serve as "lights," and also to illuminate the ammeter and the voltmeter, by which the rider can see at any moment the amount of the current and the E.M.F. between the terminals of the motor, and thus calculate the horse-power which is being expended in propelling the machine. At the left side of the seat is a commutator by which the number of accumulators in circuit can be varied, and by which the current can be altogether cut off from the motor. The full power can be obtained only by turning the switch of the commutator through the intermediate powers, so that shocks are avoided on starting the machine. The tricycle is, as mentioned above, an ordinary one converted; but Profs. Ayrton and Perry have designed a machine specially adapted for being propelled electrically, which will have the advantage of carrying the rider and the accumulator on springs and probably treadles to assist in driving the machine up steep hills.



THE ELECTRIC TRICYCLE.

ELECTRICAL CONDUCTORS.

AT a recent meeting of the Institution of Civil Engineers, a paper was read on "Electrical Conductors" by Mr. W. H. Preece. The author stated that the first aerial conductors were made of copper, and the first gutta-percha-covered wires were of iron; but the positions were soon changed, copper being universally used for insulated conductors, and iron, until lately, for overhead lines. Sir William Thomson detected great variations in the quality of copper, and Matthiessen detected the causes, and established a standard of purity. Such improvements have been made in the quality, that copper wire was now twice as good as it was in 1856. Increased speed of working, improved efficiency of apparatus, and reduced waste of energy had followed the great increase in the purity of the copper. Temperature was a disturbing agent in the conductivity of the wire. Resistance increased more than 20 per cent. between winter and summer temperatures. Copper had recently been much used for aerial lines; it was less attacked by acids, and had great durability.

Hard-drawn wire was now produced which had a breaking strain of 28 tons on the square inch, iron wire giving only 22 tons on the same area. Age did not seem to affect its quality, nor did it appear to be influenced by the currents of electricity employed for telegraphic purposes. The conductors of all cables remained constant. Lightning was supposed to render it brittle. The ultimate effect of the powerful currents employed for electric lighting was not yet known. The size of conductors was controlled by commercial considerations. Sir William Thomson had laid down the law that should control the size of leads for electric light, while that for cables followed strictly theoretical conditions. The best copper for electrical purposes came from Japan, Chili, Australia, and from Lake Superior; but much pure copper was obtained by electro-deposition, either di-

rectly from a solution, or by using impure copper as the anode in a depositing bath.

Electro-deposited copper had not the strength of ordinarily refined copper. The electrical resistance of commercial iron was from six to seven times that of copper, but its variation, due to the presence of impurities, was even greater. The weight of a cylindrical wire one mile in length and giving one ohm resistance at 60° Fahr., was called an ohm-mile. While the first iron wire was specified to give an ohm-mile of 5,500 lb., it was now obtained as low as 4,520 lb., and the maximum resistance was specified at 4,800 lb. The ordinary best puddled iron was at present used only for fencing purposes, but a mild English Bessemer steel was largely used for railway telegraphs and for stays; however, the resistance was very high, owing to the presence of manganese.

The wire used by the Post Office was made from Swedish charcoal iron, with an ohm-mile resistance of about 4,520 lb. Swedish Bessemer, or a specially prepared low carbon English Bessemer, was adopted by the Indian Government, with an ohm-mile resistance of about 5,000 lb. Cast steel wire, with a breaking weight of about 80 tons to the square inch, had been adopted on the Continent for telephone currents, with an ohm-mile resistance of 8,000 lb., while in England, where speed of working was the prime consideration, and length of span was negligible, electricians were satisfied with a breaking strain of 22 tons on the square inch; in the colonies, where long spans were essential, and speed of working was not so important, the specification of 30 tons on the square inch. The electrical conductivity of iron increased with the percentage of pure iron, except where the percentage of manganese was high; an increase in the percentage of manganese augmented the electrical resistance considerably more than an increase in the percentage of sulphur or phosphorus.

The durability of iron wire was maintained by galvanizing. When the galvanized wire was to be suspended in smoky districts, it was additionally protected by a braided covering, well tarred. In some countries galvanizing was not resorted to, but dependence was placed on simple oiling with boiled linseed oil. Such a wire was erected in 1856 between London and Crewe, but the result was very unsatisfactory. More recently (1881) the experiment had been repeated with a similar result. In this climate galvanization was imperative. But it was not alone in smoky districts that iron wire decayed. It suffered much along the seashore. The salt spray decomposed the zinc oxide into soluble compounds, which were washed away and left the iron exposed, and this was speedily reduced to mere thin red lines. Where external decay was not evident, time seemed to have no apparent effect on iron wire. Thirty-nine years of incessant service in conveying currents for telegraphy had not apparently altered the molecular structure of the iron wires in the open country on the London and South-Western Railway.

Swedish charcoal iron was imported either in bloom or in rods, principally in rods. Each rod was rolled down to about 0·26 inch in diameter, and weighed on the average about 1 cwt. Iron wire could be rolled and drawn into coils 0·171 inch in diameter, weighing 400 lb. and measuring 1 mile; but 110 lb. was about the best practical limit for transport and use. The Swedish iron owed its value, not only to its comparative purity, but to the fact that it was smelted and puddled entirely with charcoal. The best qualities were a mixture of various ores, and they were known by various brands, the conditions determining those brands being secrets.

The operation of testing was a most important one, and requisite not only for the user, but also for the manufacturer. Flaws, impurities, faults, notwithstanding the greatest care, would occur, and they could be detected only by the most rigid examination and tests. Tests were mechanical and electrical. The mechanical tests embraced one for breaking strain, another for elongation, and a third for resistance to torsion. For hard steel wire, in place of the torsion test it was usual to specify that the wire should bear wrapping round its own diameter and unwrapping again without breaking. The electrical test was simply that for resistance —$\frac{1}{10}$ of a mile of the wire to be examined was wound round a dry wooden drum, and its electrical resistance was taken in ohms by means of a Wheatstone bridge.

Galvanization was tested by dipping in sulphate of copper, and by bending or rolling round a bar of varying diameter, according to the size of the wire. Special machines were constructed for the mechanical tests, the condition to be fulfilled being that for the breaking strain the increasing load or stress should be applied uniformly, without jerks or jumps, and the elongation machine should correctly register the actual stretch without the wire slipping. The resistance to torsion of the wire was determined by an ink mark which formed a spiral on the wire during torsion, the number of spires indicating the number of twists taken before breaking. The perfection to which the manufacture of iron wire had been brought was very much due to the care bestowed upon the specifications by the authorities of the Post Office. The standard had been gradually raised, until it had attained a very high one. Many administrations objected to the expense of thorough inspection, with the result that they were the recipients of the rejected material of those who did rigidly inspect.

One break in the wire cost far more than its inspection, and one extra ohm per mile affected the earning capacity of the wire in inverse proportion. It was, however, necessary to remark that the mechanical quality of charcoal iron wire sometimes changed with time—its electrical quality remaining unaffected. Tests repeated at some subsequent period might therefore be deceptive unless allowance were made for the effect of time. Bessemer or homogeneous iron wire as a rule improved in its mechanical properties by being kept in stock. The Post Office authorities had decided to abandon a gauge altogether as applied to conductors, and to define size by diameter and weight. In future, all copper wires would be known by their diameters in "mils," or thousandths of an inch, and all iron wires by their weight in lb. per mile. Steel wire was used for long spans, or for places where great tensile strength was needed; but it was for the external strengthening of deep sea cables that steel wire was principally adopted.

It was first employed in the Atlantic cable of 1865 for this purpose. It had been since generally used for deep sea cables. The usual diameter was 0·099 in., and it was specified to bear a breaking strain of 1,400 lb., which was equivalent to 81 tons on the square inch. Steel wire had been produced giving a much higher tensile strength. A compound wire of steel and copper was introduced in America about 1874, and it had been extensively tried in both hemispheres, but without success. Recently a compound wire had been erected between New York and Chicago, a distance of 1,000 miles, giving only 1·7 ohms resistance per mile. It had a steel core 0·125 inch in diameter, and was coated with copper electrolytically to a diameter of 0·25 inch. It weighed 700 lb. per mile. Hard drawn copper, or silicious bronze of a much lighter character, would be equally efficient.

Phosphor-bronze, the hard mechanical qualities and great resisting powers of which were well known, was introduced for telegraph wire about five years ago. Several lengths were erected by the Post Office. Two long spans crossed the channel that separated the Mumbles Lighthouse from the headland near Swansea. The object in view was to obtain great tensile strength with a power to resist oxidation, especially active where the wire was exposed to sea spray. This was done in 1879, and in November, 1883, not the slightest change was noticeable in the wire. But phosphor-bronze, though extensively used, had high electrical resistance; its conductivity was only 20 per cent. that of copper.

Moreover, the phosphor-bronze supplied was irregular in dimensions and brittle in character. It would not bear bends or kinks. A new alloy, silicious bronze, had recently been introduced to remedy these disadvantages. Phosphor-bronze had disappeared for telegraph wire, and had been replaced by silicious bronze. The electric resistance of silicious bronze could be made nearly equal to that of copper, but its mechanical strength diminished as its conductivity increased. Wire whose resistance equaled 90 per cent. of pure copper gave a tensile strength of 28 tons on the square inch; but when its conductivity was 34 per cent. of pure copper, its strength was 50 tons on the square inch. Its lightness, combined with its mechanical strength, its high conductivity, and indestructibility, rendered it eminently adapted for telegraphs. If overhead wires were erected of such a material, upon sightly supports, and with some method, there would be an end to the meaningless crusade now made in some quarters against aerial lines. These, if constructed judiciously, and under proper control, were far more efficient than underground lines.

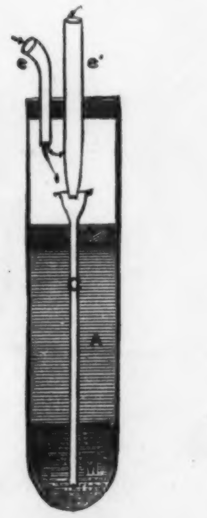
Corporations and local authorities should control the erection rather than force administrations to needless expense and to reduced efficiency by putting them underground. Not only did light wires hold less snow and less wind, but they produced less electrical disturbance, they could be rendered noiseless, and they allowed existing supports to carry a much greater number of wires. German silver was employed generally for rheostats, resistance coils, and other parts of apparatus in which high resistance was required. It consisted of copper four parts, nickel two parts, and zinc one part. It possessed great permanence, and the variation in its resistance due to changes of temperature was small. The effect of age on German silver was to make it brittle. Mr. Willoughby Smith had found a similar change with age even with wire drawn from an alloy of gold and silver. The form and character of electrical conductors must vary with the purposes for which they were intended.

For submarine cables and for electric light mains, where mechanical strength was not required, and where dimensions were of the utmost consequence, the conductors must be constructed of the purest copper producible, for copper was the best practical material at command. For aerial lines they must not only have great tensile strength, but in these days of high speed apparatus they must have high conductivity, low electrostatic capacity, expose to wind and snow the least possible surface, and must be practically indestructible. Iron had hitherto occupied the field, but copper and alloys of copper seemed destined in many instances to supplant that metal, and to fulfill all the conditions required in a more efficient way, and at no greater cost per mile.

A SIMPLE AND SENSITIVE THERMOSTAT.

By N. A. RANDOLPH, M.D.

OF the many devices employed to maintain a constant temperature in water-baths or air-chambers the great majority are either expensive, bulky, or unresponsive to slight thermic changes. The instrument about to be described presents no



claim to novelty, except in the method in which alcohol is employed to increase its sensitiveness, but it occupies very little space, and can be made by any one, at an expense so slight as to render it available to every student.

Take an ordinary 6 inch by 1 inch test-tube, and pour in sufficient distilled mercury to fill the bottom of the tube to a height of one and one-quarter inches. Fill the tube to two inches above the level of the mercury with rectified alcohol; force down a tight-fitting flat rubber cork, having one central perforation, until its lower surface just touches the alcohol, care being taken that no air bubbles are included. Then introduce through the hole in the cork a narrow tube, flared funnel shape, nearly half an inch in width at its upper end. This tube should fit very closely to the cork, and its lower end should reach to within an eighth of an inch of the bottom of the test-tube. Another flat and closely fitting rubber cork should be provided, in which are two holes, one in the center, the other to one side. In the central hole is introduced a tube, the lower end of which is somewhat drawn out, so as to easily enter the enlargement at the top of the first tube. On one side of the second central tube, and about three-fourths of an inch from its narrowed end, a minute hole should be filed or blown of a diameter just sufficient to permit the passage of enough gas to keep a flame alive; the second (lateral) hole in the upper cork is fitted with a plain short tube, which is connected with the gas supply, the top of the central tube being connected with the burner warming the water-bath or other vessel.

The completed apparatus is shown in section in the engraving, in which M represents the mercury, A the alcohol, C the funnel-tube projecting through the two liquids, e the gas admission tube, and e' the gas exit tube provided with the small opening referred to, to keep the flame from being entirely extinguished.

The thermostat being placed in the same vessel with the material requiring a constant temperature, all the gas supplying the flame beneath the vessel is passed through the instrument and its volume modified as follows:

Upon any increase of temperature the alcohol can expand only downward, pushing the mercury up the lower central tube until it seals the lower end of the upper central tube, through which by far the major part of the gas (which enters by the lateral tube) escapes.

The flame being now reduced, any fall in temperature in the medium surrounding the thermostat and the material under observation will be followed by a descent of the mercury in the lower central tube, with a consequent unsealing of the main exit of the gas supplying the flame.

The instrument may be adjusted to maintain any temperature within certain limits by moving the upper central tube up or down, as the case requires. In the first adjustment a thermometer is necessary, but after the precise height to which the mercury rises at the required degree of heat is determined, the lower end of the upper central tube may be fixed at that point, and no further adjustment will be required for some time.

Should the minor gas exit (whose office is to permit the passage of just enough gas to preserve a mere point of flame) prove too large, the defect is easily remedied by pushing into the tube a small piece of paper, so bent as to accurately fit the interior of the tube, until the passage of gas through the minute hole is retarded to the proper degree.

A good glass-blower can make this instrument in one solid piece, in which case the adjustment (after the introduction of the alcohol) must be made by the addition or withdrawal through a capillary tube of minute globules of mercury.

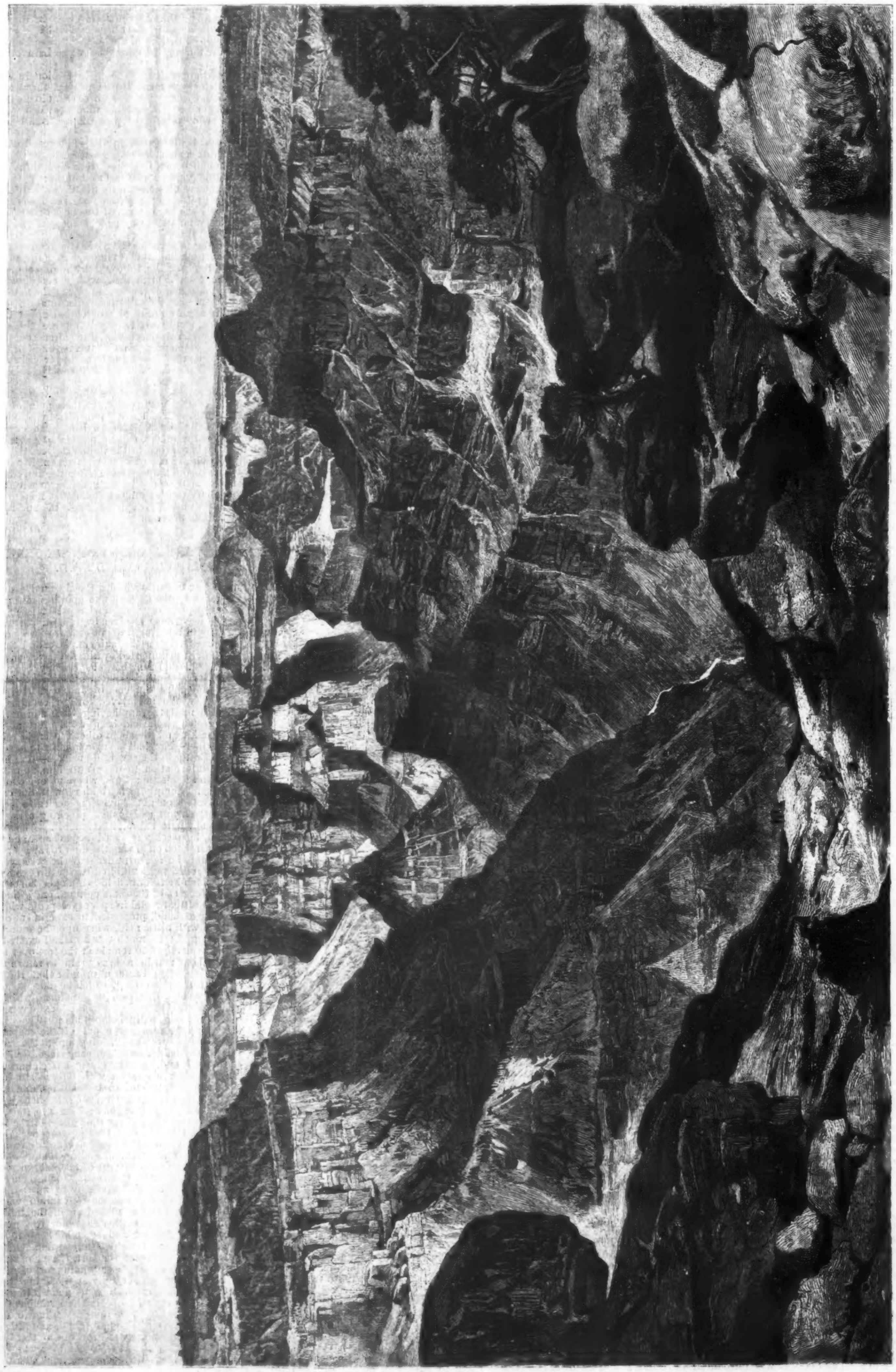
The instrument must always be kept in an upright position.—*Franklin Journal.*

GENERAL SUTTER'S ACCOUNT OF THE ORIGINAL CALIFORNIA GOLD FIND.

BEFORE going on to further notice the changed condition of things produced by the discovery of gold in California, it may not be out of place to say a few words touching the accounts of that occurrence as given by different parties who had some agency in bringing it about or were in a position to speak authoritatively on the subject. General Sutter's version of the affair, as imparted by him to the writer, varies but little from that of Marshall, as already recounted. According to General Sutter's statement, Marshall, leaving the mill some time near the end of January, 1848, came down to the fort, where he arrived toward evening, wet and covered with mud, the day having been stormy. His visit was unexpected, as he had been to the fort not long before. After talking a little about other matters he told his employer or partner—Marshall always claiming to have been interested with Sutter in the saw-mill business—that he had some important information to impart to him, so much so that he wished to see him apart and where no one could see or overhear them. Complying with his request, Sutter took him into his private room; but having neglected to lock the door, a clerk entered just as Marshall, plucking a rag from his pocket, was about to exhibit its contents. Alarmed at the interruption, he quickly replaced the package, and when the intruder left insisted on having the door to the apartment locked. This done, he again pulled out the package, and undoing a much soiled rag, exhibited two or three ounces of yellow metal, which he informed his employer he believed to be gold. Sutter was of the same opinion, and after reading a description of that metal in an encyclopedia which he happened to have at hand, proceeded to experiment on the dubious material with nitric acid, whereupon he found it to be unmistakably gold. So much was Marshall excited over the matter that he declined to remain at the fort over night, but left at a late hour and in a heavy rain to return to the mill, after exacting from Sutter a promise that the latter would follow him in the morning, which he did.

General Sutter relates that, despite the storm, which still continued, he started at an early hour the next day for the mill. While on his way, and when out about twenty miles, he saw to his surprise a man come out of the chaparral a short distance ahead of him. Riding up to the spot, he found this to be Marshall, who had already since leaving the fort been to the mill, and, there procuring a fresh horse, had returned thus far, when, overcome with fatigue and loss of sleep, he made a halt, crawled into the bushes, and took a nap. When Sutter came up, having so refreshed himself and rested his animal, he had already gotten into the saddle and was about resuming his journey toward the fort. When interrogated as to his object in returning so soon, nothing very definite could be gotten out of him; the pretense that he had come on to meet the General and see that he did not miss the trail being evidently no part of his real purpose, as Sutter had already been over the road, which, being well marked by wagon travel, could not easily be missed. The truth was, that Marshall had become so excited when it was shown that the stuff he had picked up in the mill-race was really gold that he could neither sleep nor rest until he had his partner on the ground and something as to their future course of action had been determined upon. Hence this speedy setting out again for the fort, the poor man, in his anxiety, fearing that Sutter, an easy-going sort of person, might delay his coming, or, not fully appreciating the importance of the occasion, might fail to come altogether. This frame of mind on the part of Marshall sufficiently refutes the idea entertained by some that he was long in doubt as to the character of the metal he had found, and little conscious of the consequences likely to grow out of that event. He was not long in taking measures to confirm, what from the first he suspected, that the metal was gold, nor did he fail to comprehend the results that might be expected soon to follow.

On reaching the mill Sutter entered the race with Marshall, and walking down it picked up with his own hand several particles of gold. Adding these to some other pieces



THE TRANSEPT IN THE KAIBAB, GRAND CANON, COLORADO RIVER.

given him at the time by the workmen, he had a ring manufactured therefrom, on the inside of which was engraved the following inscription: "The first gold discovered in January, 1848."

THE FIRST PIECE OF METAL PICKED UP BY MARSHALL, AND MRS. WIMMER'S VERSION OF THE GOLD-FIND.

While the sentence as above inscribed was in some sense true, this ring of General Sutter did not actually contain the first piece of gold picked up by Marshall, though that is still in existence, and capable of being identified by many persons who at different times have seen and handled it. Owing to its size, shape, and other peculiarities, persons who have once seen this piece of gold have no difficulty in recognizing it when shown to them again. It is rather flat, rough on all sides, of irregular shape, and weighs about a quarter of an ounce, its intrinsic value being not quite five dollars.

Mrs. Jane Wimmer, wife of Peter Wimmer, who, as already stated, was cooking for the men at the mill, gives the following account of the discovery of gold, the circumstances under which it occurred, and the history of the first piece of metal picked up. Her husband and Marshall, she says, were walking together down the race, when they saw this piece of metal, both at the same time, though Marshall being a little ahead was the first to pick it up. Neither of them knew what it was, though both surmised its true character, her husband being so impressed with the belief of its being gold that he brought it to her and insisted on her boiling it in lye, which was accordingly done. After standing this test so well, Wimmer, satisfied that it must be a noble metal, urged Marshall to take some of it to the fort and submit it there to further trials, which the latter consented to do, Wimmer staying at the mill and looking after the men and the work during his absence.

Marshall carefully preserved this first piece of gold for a time, saying he intended to have a ring made from it for his mother. But finally, being about to go away, having taken out a good deal of gold dust, and fearing he might lose this first piece of gold, he gave it to Mrs. Wimmer, both as a souvenir and as a means of greater security against its being lost. This occurred in the summer of 1848, and Mrs Wimmer, who is still living, being a resident of San Luis Obispo County, has retained the specimen in her possession ever since. Though not rich, she has refused many liberal offers for it, being unwilling to part with it unless assured that it would be retained among the pioneers of California, or at least be kept in the State. Some years ago the Society of California Pioneers attempted to treat with Mrs. Wimmer for this interesting relic, which, owing to a failure of negotiations, still remains in the hands of its long-time owner.—*Mining and Scientific Press.*

THE KAIBAB, GRAND CANON OF THE COLORADO RIVER, U. S. A.

MOST people have by this time heard of that wonderful region in the southwestern part of the United States, appropriately called by its principal explorer, Major Powell, of the United States army, the Plateau Province. As the name indicates, the region is greatly elevated above the sea level, but in place of mountains there are platforms or terraces nearly or quite horizontal on their floors or summits, and abruptly terminated by long lines of cliffs. But still more remarkable is the fact that the rivers, or, to speak more correctly, the drainage channels in this district, are cut from 5,000 to 3,000 feet below the general platform of the surrounding country. All these drainage channels lead down to one great trunk channel cleft through the heart of the Plateau Province for nearly 300 miles, that is to say, to the chasm or Great Cañon of the Colorado River. This cañon has been justly described as "the most magnificent gorge, as well as the grandest geological section, of which we have any knowledge."

These tremendous ravines are entirely produced by attrition—by the ceaseless action of running water. But certain conditions are necessary to insure the success of this wonderful process. The climate must be very dry, even periodical rains must be almost unknown, while at the same time never-failing streams from distant sources must pass through this dry country; the surface strata should be of a soft, yielding character; and the fall of the surface of the land sufficiently great to insure a rapid current. It is only necessary, by the way, that the surface strata should be soft, for when once the stream has established a definite channel, it will go on eating away the rocks till it has penetrated through thousands of feet of the hardest granite. The regions where these cañons are found are almost always desert and barren.

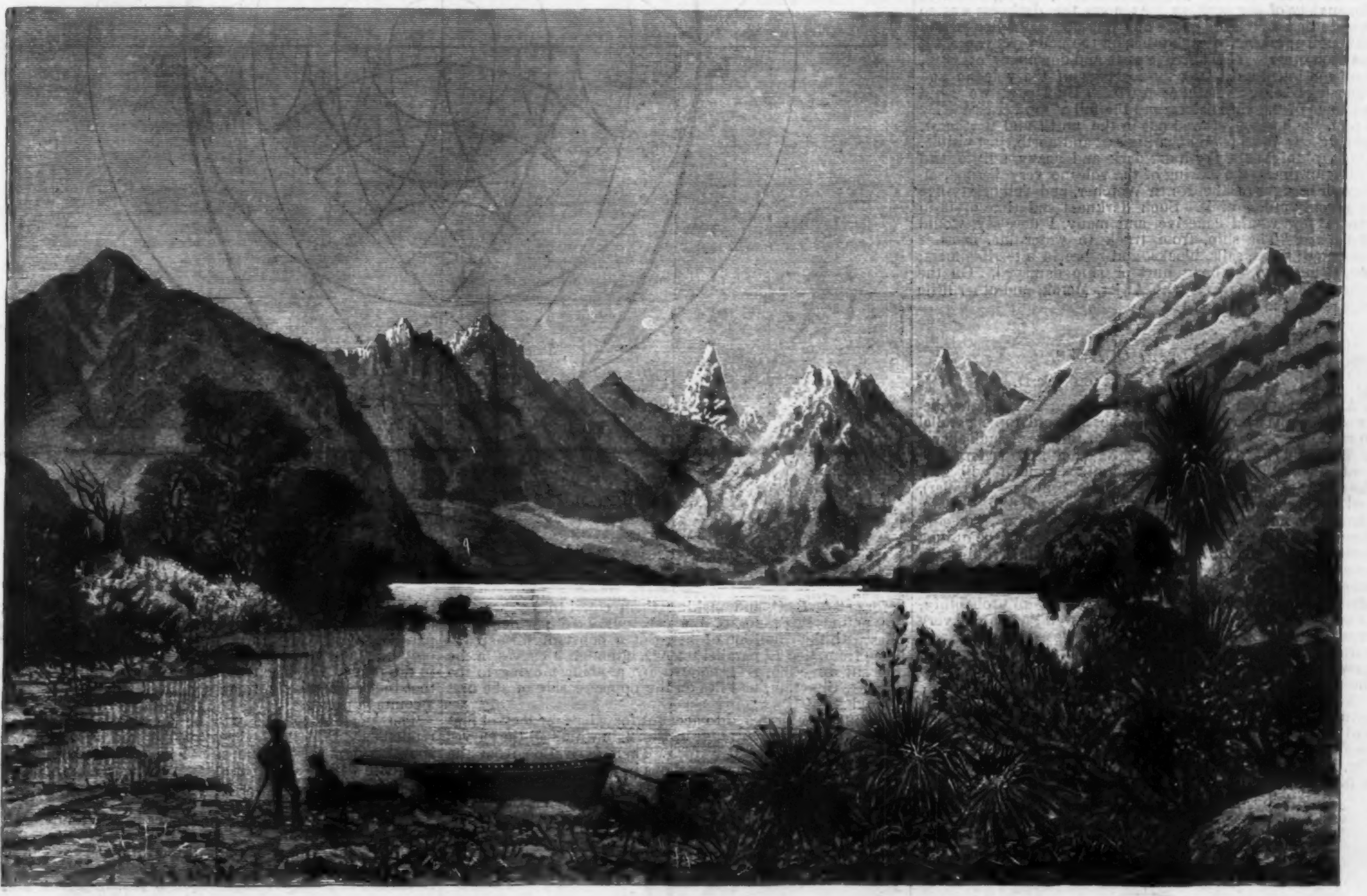
The physical geology of this region is fully described in a book written by Captain Clarence E. Dutton, U.S.A., and published by the Geological Department of the United States Government. From this exhaustive volume it will be enough to cull a few details explanatory of our engraving.

The total length of the Grand Cañon is about 218 miles, and its depth varies from 4,500 to 6,000 feet. Its width, from crest-line to crest-line, varies from 4½ to 12 miles, the widest portions being always the grandest. For convenience of discussion, Captain Dutton has classified the Grand Cañon under four divisions, of which the Kaibab is deeper, wider, and much grander and more diversified than the others. The Kiabab region lies high. Its greatest altitude is 9,280 feet above the sea level. Consequently there is more moisture and more vegetation. Large and noble trees, standing apart as in a park, abound, and during the summer there is a magnificent display of wild flowers.

The shapes of the rocks in this strange region are suggestive of the work of human hands, only on a gigantic scale. For example, there is a "butte," more than 5,000 feet high, which has a surprising resemblance to an Oriental pagoda. It was named Vishnu's Temple. In another case, a long rambling rocky mass was called the cloister. Another "butte," the most majestic of all, was christened Shiva's Temple. There are hundreds of these mighty structures, miles in length and thousands of feet in height, displaying their richly-moulded plinths and friezes, thrusting out their gables, buttresses, and pilasters, and recessed with alcoves and panels.—*London Graphic.*

NEW ZEALAND SCENERY—LAKE HAWEA.

SITUATED midway between Otago and Canterbury, Lake Hawea is one of the attractions for tourists in that portion of the Middle Island of New Zealand. In extent it is about seven miles long by four broad. On all sides it is surrounded by steep hills, mostly of a barren and naked character, except where they are partly covered by brush. There is little level land in the vicinity, but some ground of that description at the southern end of the lake has proved tolerably productive. There is a considerable traffic in wool and timber, the latter being cut from the sides of the mountains and the former produced in the immediate adjacent country. Both timber and wool are floated on rafts across the lake to the mouth of the river Molyneux, which with the Hunter is its chief source. It is also fed by several smaller streams. The sketch we give represents Lake Hawea, as seen from the eastern side, looking west. Far in the distance Mount Aspiring, 9,920 feet above the level of the sea, may be discerned, standing on the western side of Lake Wanaka. It marks the provincial boundary in that quarter. Lake Hawea, it may be added, is noted for its great depth—as much in many places as 1,200 feet. It is 1,000 feet above sea-level.—*Town and Country Journal.*



NEW ZEALAND SCENERY.—LAKE HAWEA.

THE JAVA EARTHQUAKE.

THE following letter from the Liverpool *Daily Post*, received from Capt. W. J. Watson, of the British ship Charles Bal, contains a graphic and interesting account of the terrible volcanic outburst in Sunda Straits in August, 1883. Capt. W. J. Watson was himself an eye-witness of what he describes. His vessel was actually within the Straits, and not far from Krakatoa when that island had become an active volcano:

"*August* 22, 15° 30' S., 105° E.—About 7 p.m. the sea suddenly assumed a milky-white appearance, beginning to the east of us, but soon spreading all round, and lasting till 8 p.m. There were some clouds (cumulus) in the sky, but many stars shone, and in the east to northeast a strong white haze or silvery glare. This occurred again between 9 and 10 p.m., the clouds also appearing to be edged with a pinkish colored light, the whole sky also seeming to have extra light in it, similar to when the aurora is showing faintly. On the 24th, in 9° 30' S. 105° E., we had a repetition of the above. On the night of the 25th, standing in for Java Head, the land was covered with thick, dark clouds and heavy lightning. On the 26th, about 9 a.m., passed Prince's Island, wind southwest, and some heavy rain; at noon, wind west-southwest, weather fine, the island of Krakatoa to the northeast of us, but only a small portion of the northeast point, close to the water, showing; rest of the island covered with a dense black cloud. At 2:30 p.m. noticed some agitation about the Point of Krakatoa; clouds or something being propelled from the northeast point with great velocity. At 3:30 we heard above us and about the island a strange sound as of a mighty, crackling fire, or the discharge of heavy artillery at second intervals of time. At 4:15 p.m., Krakatoa north half east, ten miles distant, observed a repetition of that noted at 2:30, only much more furious and alarming, the matter, whatever it was, being propelled with amazing velocity to the northeast. To us it looked like blinding rain, and had the appearance of a furious squall of ashen hue. At once shortened sail to topsails and foresail. At five the roaring noise continued and increased; wind moderate from south-southwest; darkness spread over the sky, and a hail of pumice-stone fell on us, many pieces being of considerable size and quite warm. Had to cover up the skylights to save the glass, while feet and head had to be protected with boots and southwesters. About six o'clock the fall of larger stones ceased, but there continued a steady fall of a smaller kind, most blinding to the eyes, and covering the decks to three or four inches very speedily, while an intense blackness covered the sky and land and sea. Sailed on our course until we got what we thought was a sight of Fourth Point Light; then brought ship to the wind, southwest, as we could not see any distance, and we knew not what might be in the Straits, the night being a fearful one. The blinding fall of sand and stones, the intense blackness above and around us, broken only by the incessant glare of varied kinds of lightning and the continued explosive roars of Krakatoa, made our situation a truly awful one. At 11 p.m., having stood off from the Java shore, wind strong from the southwest, the island, west-northwest, eleven miles distant, became more visible, chains of fire appearing to ascend and descend between the sky and it, while on the southwest end there seemed to be a continued roll of balls of white fire; the wind, though strong, was hot and choking, sulphurous, with a smell as of burning cinders, some of the pieces falling on us being

like iron cinders, and the lead from a bottom of thirty fathoms came up quite warm. From midnight to 4 a.m. (27th) wind strong, but very unsteady, between south-southwest and west-southwest, the same impenetrable darkness continuing, the roaring of Krakatoa less continuous, but more explosive in sound, the sky one second intense blackness and the next a blaze of fire, mastheads and yardarms studded with corposants, and a peculiar pinky flame coming from clouds which seemed to touch the mastheads and yardarms. At 6 a.m., being able to make out the Java shore, set sail, passing Fourth Point Lighthouse at 8; hoisted our signal letters, but got no answer. Passed Anjer at 8:30, name still hoisted, close enough in to make out the houses, but could see no movement of any kind; in fact, through the whole Straits we have not seen a single moving thing of any kind on sea or land. At 10:15 a.m. passed the Button Island one-half to three quarters of a mile off; sea like glass round it, weather much finer looking, and no ash or cinders falling; wind at southeast, light. At 11:15 there was a fearful explosion in the direction of Krakatoa, now over thirty miles distant. We saw a wave rush right on to the Button Island, apparently sweeping right over the south part, and rising half way up the north and east sides. This we saw repeated twice, but the helmsman says he saw it once before we looked. The same wave seemed also to run right on to the Java shore. At the same time the sky rapidly covered in; the wind came strong from southwest by south; by 11:30 we were inclosed in a darkness that might almost be felt, and at the same time commenced a downpour of mud, sand, and I know not what; ship going northeast by north, seven knots per hour under three lower topsails, put out the side-lights, placed two men on the look-out forward, while mate and second-mate looked out on either quarter, and one man employed washing the mud off binnacle glass. We had seen two vessels to the north and northwest of us before the sky closed in, adding much to the anxiety of our position. At noon the darkness was so intense that we had to grope our way about the decks, and although speaking to each other on the poop, yet could not see each other. This horrible state and downpour of mud, etc., continued until 1:30, the roarings of the volcano and lightnings being something fearful. By 2 p.m. we could see some of the yards aloft, and the fall of mud ceased. By 5 p.m. the horizon showed out in the north and northeast, and we saw West Island bearing east and north, just visible. Up to midnight the sky hung dark and heavy, a little sand falling at times, the roaring of the volcano very distinct, although in sight of the North Watcher, and fully sixty-five or seventy miles off it. Such darkness and time of it in general few would conceive, and many, I dare say, would disbelieve. The ship, from truck to water-line, is as if cemented; spars, sails, blocks and ropes in a terrible mess; but, thank God, nobody hurt or ship damaged. On the other hand, how fares it with Anjer, Merak, and other little villages on the Java coast?"

PARALLEL CURVES.

By Prof. C. W. MACCORD, Sc.D.

ANY two curves so related that the normal distance between them is everywhere the same are said to be parallel to each other. A familiar example of the use of such curves is found in the construction of a cam and roller: the contour of the cam is first determined which will give the required motion to a mere point (the center of the roller), and the problem then is to draw a curve parallel to this, at a distance from it equal to the radius of the roller. The construction of the second curve by points might be quite a tedious and difficult process, since it would require the erection of normals to the first at short distances from each other, upon which the given radius must be set off. And after all the parallel curve would not be, in all probability, as accurately determined as it is by the well known and very expeditious method of describing a series of circular arcs with the given radius, having their centers in the original curve; then the required working outline is tangent to all these arcs.

Now the condition of parallelism between two curves naturally suggests the idea of similarity in form; but as will presently appear, this does not always exist. There is no difficulty in perceiving or believing that the three curves in Fig. 1 are parallel to each other; but at first glance one is hardly likely to be struck by the fact that all the various curves

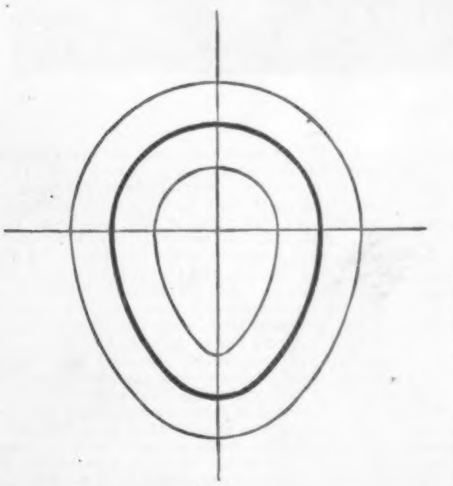


FIG. 1.

shown in Fig. 2 are also parallel. Careful study, however, will show that this is really the case; but the way in which these apparently contradictory results are obtained, and so many dissimilar figures developed from one original, can best be seen by considering the process in detail.

In Fig. 3, taking AD as the original curve, and constructing a parallel by the first of the methods above described, we draw normals at various points A, B, C, etc., and setting off on each of these a given distance, Aa for example, the points a, b, c, etc., of the derived curve, are thus determined. Or, we may regard ad as generated by the extremity a of a right line which is always normal to the given path AD of its other extremity A.

In this diagram, AD is a circular arc whose center is P. And we observe that so long as the points A and a lie on the same side of the center, the curves AD and ad will lie on the same side of AP, their generating points move in the same direction from that line, and their curvatures are in the same direction. Confining our attention now to the case in which Aa is measured from A toward P, so that the derived curve lies on the concave side of the original one, we note that as a approaches P the length of ad diminishes; and when finally Aa becomes equal to AP, the parallel curve degenerates into the point P. Which is only a new way of expressing the sufficiently familiar fact, that the circumference of a circle is everywhere equally distant from its center.

Let us next go a little farther, and assume a normal distance APa', greater than AP. Drawing normals to AD as

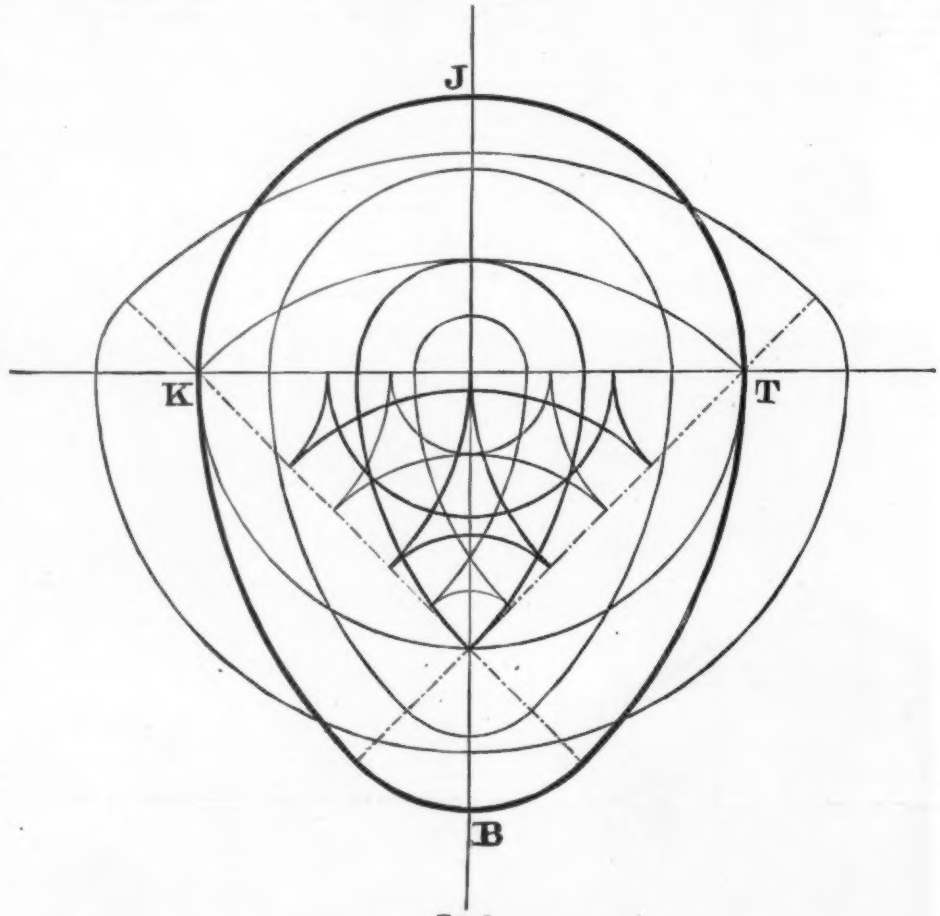


FIG. 2.

before at A, B, C, and making them equal to Aa', we find the points b', c', etc., of the new curve a'd'; which complies with the condition of being at a constant normal distance from, that is, parallel to, AD, although it curves in the opposite direction, is generated by a point moving in the opposite direction, and lies on the opposite side of the first normal APa'.

We are now prepared to account for whatever may at first sight have appeared strange in Fig. 2, in which all the curves are made up of circular arcs. Their derivation from the original oval JKBT may perhaps be more readily traced by the aid of Fig. 4; in which ADE is a curve composed of the arc AD, whose center is P, and another arc tangent to it, whose center is O. Then it is very obvious that ad is parallel to AD, and dL to DE, the constant normal distance being Aa. If that distance be made equal to AP, the result is that

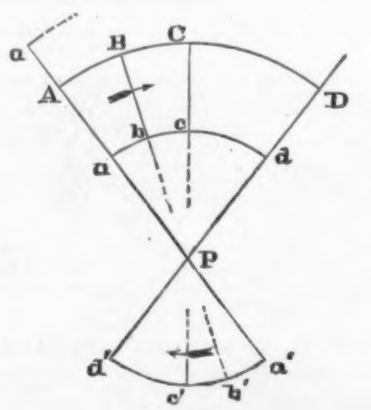


FIG. 3.

the parallel to AD is reduced to the point P, and PM is the parallel to DE. Going beyond this, when the normal distance is Aa', we have a'd' parallel to AD, but since Dd' is less than DO, the arc d'N, parallel to DE, will still be concave in the same direction, and thus is formed a cusp at d', where the two portions of the parallel curve are tangent to each other.

What has thus been shown in relation to arcs of circles, will apply with slight modification to other curves; as will be readily seen when it is considered that a circular arc may always be found, which for a greater or less distance will deviate but imperceptibly from any portion of any given curve. Indeed, the original oval in Fig. 2 very closely resembles the path of a point upon the piston rod of an oscillating engine, and had that curve been actually used, it is quite apparent that a very similar series of parallels would have resulted.

When the derived or parallel curve lies on the convex side of the original one, as does the outer curve of those shown in Fig. 1, it is self-evident that none of these peculiarities will be exhibited, and that the two will be in a general way similar in form. But when the contrary is the case, the manner in which a cusp may be formed, and the conditions under which it will be, are illustrated in Fig. 5; the original curve VE being of such a nature that its radius of curvature is least at the vertex V, and continually increases toward E. Drawing, as in Fig. 3, normals of equal length at various points A, B, etc., we come presently to a point D where the radius of curvature is exactly equal to the given constant normal distance. The extremities v, a, etc., of these normals determine the curve v, d, which is the parallel to VD, just as a' d' was to AD in Fig. 3; the only points of difference between the two cases being that in the present instance the curves are not circular arcs, and that the consecutive normals do not intersect each other in a common point.

The parallel to DE will be convex in the same direction as DE itself, because the radius of curvature is everywhere greater than the distance between the curves; and there will be a cusp at d, because the two branches v d, d e, have at that point a common normal D d, and therefore a common tangent.

Should the given normal distance be less than the least radius of curvature, as for example Vx, it is quite obvious that the parallel curve x y z will not form a cusp; and if the original line VDE curve always in the same direction, the formation of a cusp further requires that the given normal

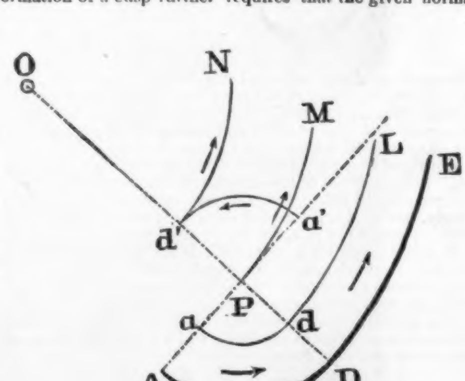


FIG. 4.

distance shall be less than the greatest radius of curvature. But if D be a point of contrary flexure, and the given normal distance V v be greater than the least radius of curvature of V D, then d will be a point of cuspidation, whatever the radius of curvature of the contrary curve D E or of any portion thereof.

But, as is shown in Fig. 2, the parallel curve will not form a cusp, although lying on the concave side of the original, if the distance between them be greater than the greatest radius of curvature of the latter.

And this leads to a development which might in some circumstances be of utility in the construction of cams. In most instances, it may be admitted, the original or ideal

outline of a cam will be of such a form that the roller will be sufficiently large, if its radius be less than the least radius of curvature; in which case no difficulty is met with. But it is conceivable that the requirements of the mechanism should imperatively call for the employment of a cam, whose radius of curvature is exceedingly small at certain points. For example, the original outline of the cam VDE in Fig. 6 is composed of two cycloids, the radius of

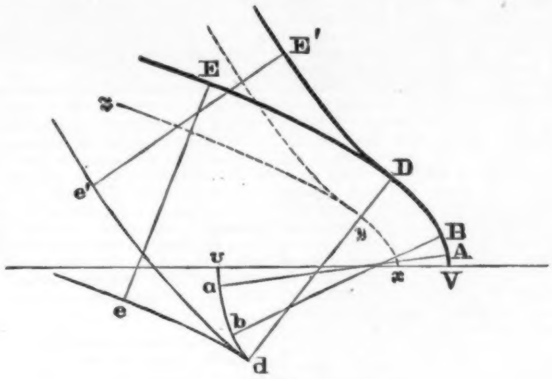


FIG. 5.

curvature at the vertices V and E being in this case zero. The derivation from this, of a *convex* cam with a roller of any moderate radius such as would naturally at first suggest itself, is manifestly impossible, as giving rise to the intersecting and cuspidating curves shown at O. But by sufficiently increasing the radius, making it equal to VF, for example, we derive the working contour FHK, which will

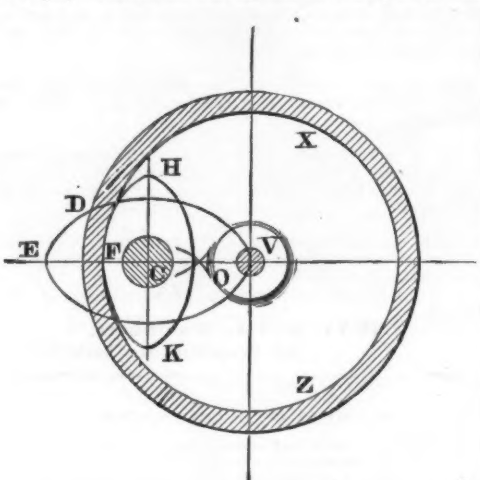


FIG. 6.

give the required motion to a *hollow* roller F X Z, within which it revolves about the center C. It is necessary in this construction to take care that VF be greater than the greatest radius of curvature of the original. The roller is much larger than the working cam; and this unusual proportion at first gives an impression of a want of compactness. But this is more apparent than real, as will be seen

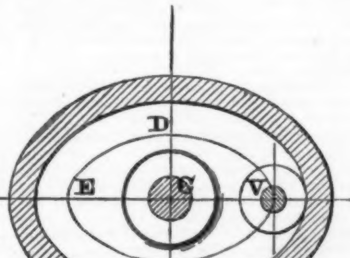


FIG. 7.

by comparing Fig. 6 with Fig. 7, which latter shows the result of using the concave or hollow cam, derived in the ordinary manner from the same cycloidal outline VDE. In this case the working contour lies wholly outside of the original curve, and although the roller is as small as could be advantageously employed, the dimensions of the cam are so greatly increased that this arrangement, in respect to compactness, has very little advantage over the other.

A CAMERA LUCIDA.

THE camera lucida is an apparatus which renders great services to landscape painters by permitting them to see upon their canvas or drawing-paper the landscape that they wish to reproduce, and to sketch its outlines with an accuracy and rapidity that cannot be attained by means of the unaided eyesight. For reducing or enlarging drawings, maps, plans, etc., the camera lucida also gives excellent results. In short, this instrument forms part of the professional tools of the majority of artists, designers, engravers, etc.

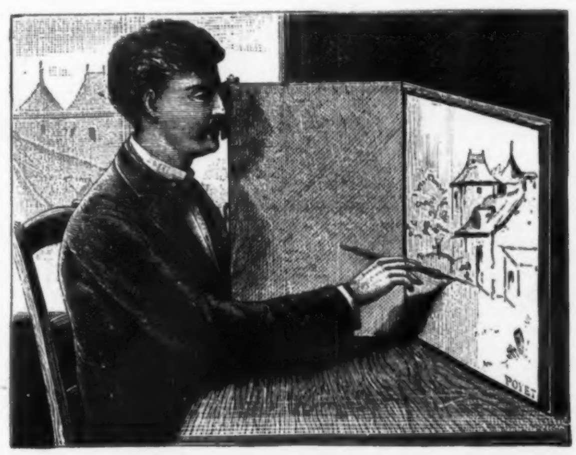
The cameræ lucidæ invented by Wollaston have since been more or less improved upon, but all are based upon the same principle. They consist, as well known, of a right angled triangular prism, one of whose faces is covered with a small mirror. The rays, proceeding from the object whose image it is desired to see, first meet the prism, where they are refracted at their entrance and exit and then strike the mirror, and from this are reflected so that the draughtsman receives them in the direction of the sheet upon which he wishes to draw, and is thus enabled to trace their contours with a pencil. But a Wollaston camera lucida costs all the way from 30 up to 60, 80, and 100 francs, thus necessitating a considerable outlay. Now it is possible to obtain the same effects as are given by this apparatus, by using a simple mirror, or any bit of silvered glass, this fact being due to a physiological peculiarity of our vision.

When we look at an object each of our eyes perceives its image, but the two images are superposed, and we thus have a perception of but a single object. If, by a slight pressure upon one of our eyes, we move the globe of the latter, while looking at the same object, the two images will be perceived separately, or, in other words, we shall see double.

It is probable that animals whose eyes have different directions, those for example that have eyes at the side, like many herbivora (hares, gazelles, etc.), or that carry them upon peduncles (like crustaceans), do not perceive superposed images as we do.

It is due to such superposition of images that when we station ourselves before a sheet of white paper affixed to a wall, and turn so as to face it, it is possible, by looking with one eye into a small mirror, to see upon the paper, by means of the other eye, a reflection of the object situated behind us, and to thus easily follow or trace its outlines. It is a very simple matter to get up a camera lucida upon this principle.

As for the arrangement of the apparatus, we may affix a small mirror with wire to the cover of an open sketch-book (see figure), and so place ourselves that we may, with the left eye regarding the mirror, see with the right a reflection of the object that we desire to draw. This image will be seen upon the vertical part of the drawing-paper in front of us, and we may then follow it in all its outlines and details, as we would do with an ordinary camera lucida.



AN EASILY-MADE CAMERA LUCIDA.

This little experiment is, as may be seen, a very easy one to try and be successful with. After the description that we have given of it, our engraving will facilitate its execution. —*La Nature.*

METHOD FOR PREPARING URANIC NITRATE OR ACETATE FROM THE RESIDUES.

By J. T. SAVORY, F.I.C.

THE precipitate of uranyl phosphate, or uranyl ammonium phosphate, is washed by decantation until free from soluble salts. It is now dried, powdered and ignited to expel ammonia from the double phosphate. The resulting uranyl phosphate is then dissolved with the aid of heat in pure strong nitric acid, and while the solution is still on the water-bath, pure coarsely-granulated tin is added in small portions, in quantity equal to one-half the weight of the phosphate. When the action has ceased the mass is evaporated to dryness and gently heated on a sand-bath. The stannic oxide containing *all* the phosphoric acid is then broken up, and boiled out with successive portions of nitric acid (one in four), allowing to settle after each treatment, and filtering through Swedish paper. The solution of uranyl nitrate is then concentrated, and the salt crystallized out, and drained on a porous tile. Recrystallization is generally unnecessary.

If the acetate be required, the solution of the nitrate is evaporated to dryness, and gently heated till acid vapors are no longer given off, and the remaining uranyl oxide, which should be yellowish red if not too strongly heated, is dissolved in warm acetic acid, filtered, and the acetate crystallized out as in Wertheim's method.

It is important that the tin used shold be pure and also not too finely divided. If the powdered metal be used the action is very violent, and portions of it are fused, and even become incandescent and cause spirting. The stannic oxide produced too will be difficult to filter, being very finely divided. If the acid used be not heated, or too dilute, stannic salt may be produced, which, by slowly decomposing, would make the solution turbid.

This method gives a yield of over 90 per cent., and is less troublesome than that of Reichard.—*Chem. News.*

THE GERMAN CARP, AND ITS INTRODUCTION IN THE UNITED STATES.*

By CHAS. W. SMILEY.

1. *Systematic Position, Varieties, and Economic Relations.*—The German carp belongs to the family *Cyprinidæ* and genus *Cyprinus*. Of the *Cyprinus carpio* there are three varieties: the scaled, which is the most edible; the leather, which is the most prolific; and the mirror, which is intermediate between the other two. The common gold fish, *Cyprinus auratus* Linnæus, is an allied species, with which the German carp very readily hybridizes.

The present purpose is not to speak of carp from a biological standpoint, but from an economic one, especially as there is little that is new with reference to its biology and much that is new when economically considered.

2. *History of its Introduction.*—The carp was originally from Central Asia, whence it was introduced into Europe a few centuries ago; into England in 1504, and into Austria in 1227. It is alleged that Capt. Henry Robinson brought carp from Holland to the United States about 1830 and put them into his ponds at Newburg, N. Y., from whence they escaped into the Hudson.† As nothing practical came of this, the real introduction of carp into the United States dates from May 26, 1877, at which date Mr. Rud. Hessel arrived from Bremen with 345 carp of different varieties for the United States Fish Commission.‡ These were propagated under the direction of Prof. S. F. Baird. The distribution of their young commenced in the fall of 1879, and has continued to the present time in increasing quantities annually. The number distributed in 1879 was 6,203 to 273 applicants in 24 different States of the Union. In 1880, 31,443 were distributed to 1,374 different applicants in 34 different States and Territories. During the past season 118,605 have been distributed in lots of from 15 to 20 to each applicant.

3. *Natural History.*—The carp prefers a pond containing warm water and muddy bottom, but neither of these is absolutely essential. It feeds upon such worms and lower forms of animal life as are within its reach, but never upon other fishes. It will, however, eat its own eggs if forced to by hunger. It is very fond of vegetable food, such as lettuce, cabbage, leaves of various water plants, seeds, grain, meal, bread, crackers, corn-bread, etc. Most anything you would give to chickens you can give to carp to eat.

If the water is warm, the summer long, and there be plenty of food, either natural or artificial, the growth of the carp will be surprisingly rapid. There are well authenticated reports of it reaching three pounds in one year and six pounds in two years. If no artificial food is furnished, and there is also a scarcity of natural food, or if the climate be cold, the growth will be much less rapid. Indeed, when the water becomes quite cold it will partially bury itself in mud and lie in a dormant state through the entire winter and until spring fairly sets in. In the southern part of Texas it is probable that the carp will not be forced to hibernate at all except in case of an unusually severe winter. In the northern parts of Maine and Minnesota it may be expected to hibernate nearly half the year. As it cannot grow during its hibernation, it is easy to see why so much more rapid growth is obtained in Texas than in Vermont. There is little danger, however, of it freezing to death, for carp have survived in tubs of water over which a thick film of ice has accumulated.

Carp usually spawn in cool latitudes the third year, in temperate latitudes the second year, and there are well authenticated instances of its having spawned in Southern Texas at the age of one year. These cases, however, are where carp are supplied with an abundance of food, well cared for, and protected from their numerous enemies.

The enemies of carp are legion, and in many cases exterminate the fish. Not only do all kinds of carnivorous fish prey upon its young, but nearly all kinds of fish will eat its eggs. Frogs, snakes, and turtles will eat both eggs and young in numerous quantities. A snake was recently killed at the carp ponds in Washington in which was found over twenty-five young carp and numerous undigested skeletons of the same fish. One medium sized snake, if furnished the proper facilities, can be depended upon to eat forty carp per

* A paper read before the American Association for the Advancement of Science, at the Minneapolis meeting, 1883.

† See Bulletin of the United States Fish Commission, 1882, page 25.

‡ Report of the United States Fish Commissioner for 1877, page 43.

day, one thousand per month, or five thousand each summer. Divide your number of young carp by this figure, and you can find out how many snakes it will require to exterminate your young. Various birds, such as kingfishers, bitterns, cranes, herons, and fish hawks understand catching carp much better than the average farmer. About the 17th of July last a marsh hen was shot at the Washington carp ponds whose stomach contained thirty-eight young carp, and a night heron whose stomach contained the heads of seventy-eight young carp. In many cases where the carp have been left to the mercies of these enemies they have succumbed. The only proper method is to furnish protection to the carp until they reach such an age as to be well able to cope with these enemies. It is, therefore, best to separate the spawning carp from all other animals, and carefully protect the eggs of the young for as long a time as convenient.

In regard to the food qualities of carp, it ranks somewhat above the ordinary native fish, such as buffalo, mullet, suckers, mud-fish, croakers, mill-roach, perch, sunfish, etc., but it is hardly equal to the high-priced delicate class of fish which includes the bass, trout, and shad. And yet many persons who are cultivating carp declare them equal to any fish they ever tasted. If carp are grown in muddy or polluted water their flesh, like that of any other animal, will be impregnated thereby. But the carp may be removed to pure water for a week, during which the system will be purified, and at the end of which even these will be good eating. Some have alleged that salting such over night will greatly improve the flavor. During and immediately after the spawning season adult carp, like all other fish, become soft and unfit to eat. Some persons have ignorantly tasted of them at this season, and have therefrom very unjustly condemned them. Carp contain bones, of course, but in the adult the flesh flakes off from the bones very nicely. Even in the small ones the bones are no more objectionable than in the average fish.

4. *The Method of Distribution.*—Several breeding ponds have been fitted up at Washington from the so-called Babcock Lakes and from extensions into the Potomac marshes. These will present a very picturesque appearance, in addition to their usefulness, after the reclamation of the Potomac flats. These ponds are constantly watched by their superintendent, Mr. Rud. Hessel and his assistants, who have abundant facilities for destroying enemies, draining the ponds, supplying fresh water, food, etc. At the proper season, which extends from October 15 to January or February, the young are sent out by one of two methods: first, they are put in five and ten gallon cans of water and loaded in the cars of the Fish Commission, of which there are two fitted up with suitable appliances for carrying all kinds of fish. These cars, which present an outward appearance of parlor cars, are dispatched on passenger trains to central points in all the different States of the Union, where installments may be delivered to State fish commissioners or the carp treated by the second method. Second, a quart pail containing a pint of water and fifteen to twenty carp can be sent by express to any distance which will not require more than thirty-six to forty-eight hours, or even further, if the water can be changed meantime, always provided that water enough remains in the pail to cover the backs of the fish. Most of the States of the Union have appointed State commissioners, who receive installments from the United States Fish Commission and distribute them to applicants within their jurisdiction. Many of them have also established propagating ponds, in which they are already producing young by the thousands and tens of thousands. Some private speculators have received carp from the United States Fish Commission, reared young, and are now selling them at speculative rates. The price list of one of these gentlemen states that he will sell mirror carp ten months old at $75 per hundred, scale carp ten months old at $70 per hundred. Large fish are even sold at five dollars a pair, and would perhaps be sold at higher rates were it not for the fact that the United States Fish Commission furnishes its small fish free of cost. The express charges constitute the only expense to the recipient.

5. *Economic Results.*—The cultivation of fish is destined to become as important among the American farmers and planters as the cultivation of cattle, sheep, swine, poultry, or of grains, fruits, and berries. They have long since ceased to leave the latter to shift for themselves and to cope with their enemies, knowing that in such a struggle live stock, grains, and fruits come off second best or succumb. Fish should receive the same care and attention, both as to improving varieties, artificial propagation, and growth. The practice which farmers will obtain in carp culture will probably open the way to the successful culture of various other kinds of fish. The hardiness and wide range of diet and the rapid growth of carp especially fit it to be the precursor in fish farming. Every rural community is destined to have its fish ponds in the same abundance that it has its pig pens or its poultry yards. This will enable every farmer, however remote from market, to introduce fresh fish into his bill of fare at a very trifling cost. The carp may be made a pleasurable pet, learning to come to its food at call, if habitually fed in one place, and in shallow water, or upon a plank submerged a few inches. From these places, by reason of its tameness, it can be taken even with the hands. Finally, there is no more tasteful and economic means of decorating a plantation or a country seat than by a carp pond neatly prepared and protected. If, however, any persons should imagine that these good results are to be attained merely by filing an application for carp and upon the receipt of the fish leaving them to shift for themselves, and unaided to cope with their enemies, it is well that their minds be disabused at the first, for there is no provision of nature anywhere whereby a man shall obtain his daily bread except by the sweat of his brow.

United States Fish Commission, August 21, 1883.

THE CHINCH-BUG.

THE chinch-bug has arrived upon the borders of New England, and unless the habits of the insect are well and generally understood, and active measures adopted to prevent its spread, it will doubtless within a very few years become another of the many destructive insect pests the Eastern farmer will have to contend against. Its present eastern foothold is in St. Lawrence County, New York, the third county west of Vermont. It has not been noticed by the St. Lawrence County farmers until the present autumn, but from what is known of the habits of the insect, as also from the fact that farmers seldom recognize or pay much attention to new insects till they become both numerous and destructive, it is more than probable that it has been in the region at least two or three years. The chinch-bug is a native insect, and previous to the settlement of the country undoubtedly lived upon the native grasses, but it has learned to choose wheat and barley in preference when these grains can be found, but it feeds upon Indian corn and the other smaller grains, and also upon timothy and other grasses, when wheat or barley are not within convenient reach. It is just one hundred years ago that the bug was first noticed as a depredator upon wheat, making its first appearance in the interior of North Carolina in 1778, and was supposed at the time to be identical with the Hessian fly. Two years later the wheat of North Carolina was so overrun with the bug as to threaten a total destruction of the grain, and in some sections grain growing had to be abandoned for some years. Three years ago the United States Senate passed a resolve authorizing the printing for distribution among wheat growers of several thousand copies of a pamplet on the chinch-bug, by Professor Cyrus Thomas, entomologist to the Department of Agriculture, a copy of which has been received from the author, and to whom we are indebted for the following facts relating to the devastations caused by this unsavory specimen of insect life. In Illinois alone, according to Mr. Walsh, this insect destroyed crops in the year 1850 to the value of $4,000,000, or an average of $4.70 to every man, woman, and child then living in the State. In 1864 it appears to have become most destructive in the great Northwest and Mississippi Valley, where in a single summer it destroyed three-fourths of the wheat and one-half of the corn crop throughout extensive districts, with an estimated loss of more than $100,000,000 in the currency then prevailing. In 1871 the loss caused in the State of Illinois was estimated by Dr. Le Baron at not less than $10,500,000, and, in adjoining States, enough more to make a total of $30,000,000 from this one species of insect. In 1874 the damage over the same area must have again reached the enormous sum of $100,000,000. The loss in Missouri that year was $19,000,000 and in Illinois $30,000,000, or an average of $11.50 to each inhabitant. Its devastations vary from year to year, but it is believed that for many years past the annual damage done to the grain crop of the United States has been not less than $20,000,000, a tax that the industry of the nation can ill afford to bear, but a tax that may be increased and made specially burdensome in sections where the insect has not before been known, unless vigorous measures are taken to learn its habits, and prevent its obtaining a foothold.

It is a small insect, not more than three-twentieths of an inch in length, a true bug like the stinking squash-bug, bedbug, and the "spice" bugs, as children call them, when found on huckleberries, and takes all its food through a long beak or proboscis, with which it pierces the stems of plants and sucks their juice. When not in use this proboscis is folded under the breast. The fore part of its body is blackish, the rear portion white, with a black spot on each wing cover. The bodies of the larvæ are quite reddish, and it is in this stage that the greatest damage is done. The eggs are laid in early spring by mature insects that have lived through the winter in secluded places, as among leaves, stones, straw, or under old rails or boards. The eggs are attached to the lower part of the stems of plants, and sometimes on exposed roots, where the ground is cracked by frost. Dry weather is favorable to the development of the young, heavy showers and long continued storms often destroying a large portion of the eggs before the hatching. The eggs are not all laid at one time, nor in one place, but the females distribute them a few in a place through a period of some twenty days. Dr. Shimer's observations indicate that the usual number of eggs laid by a single female is about 500, and that from the egg to the mature insect requires about 60 days. In seasons of maximum abundance the insects are sometimes so numerous that the fields are alive with them and they become so troublesome as to interfere with ordinary farm operations, the winged insects sometimes getting so thick about plow teams as to greatly annoy horses by flying into their nostrils. Men have been driven to quit work on account of the annoyance of the living and the strench of the crushed insects. Hundreds of millions of them may be upon a single acre of wheat or corn at one time, and with so many little dumps draining the sap from the plants it requires but a few days to ruin a crop. When the wheat or barley stems get a little hard and dry as ripeness approaches, the larvæ sometimes migrate in search of food, usually attacking a corn field if one is within a hundred rods. The mature insects take to the air when in pursuit of new fields to devastate.

The lady-bug and the lace-winged fly destroy some of the insects, but the chinch-bug appears to have no natural enemy to keep it in check, so that man will have to fight him alone. A preventive measure would be the burning in autumn and cleaning up of all kinds of rubbish around a field that had been harboring the multitude during the summer, and fall plowing, to bury the insects deeply in the ground. In summer, during migration, tar water poured in a continuous stream from a teakettle, making a fence around a field over which the insects will not pass. Furrows may be plowed with perpendicular banks on one side to impede progress, and in which the insects may be destroyed by drawing over them a log, or by burying deeply in the earth.

But what we at the East ought to do is to prevent, if possible, the establishment of the pest here among us. Prof. J. A. Lintner, State Entomologist of New York, has issued, through the Experiment Station, directions for stamping out the invaders before they get beyond all control. In St. Lawrence County, where they have been found, their operations have apparently been thus far confined mostly to grass fields, destroying the soil in patches, and it is recommended to cover these dead spots and their edges for several feet with straw, and then burn it. Plow the burned area, or better still, the whole field, in broad, deep furrows, turning the soil completely and flatly over, then harrow the ground lightly, and roll with a heavy roller. This will bury beyond resurrection. Where plowing is unadvisable, gas lime, at the rate of 200 bushels per acre, is recommended to be spread broadcast upon the dead places and their edges, any time before the ground freezes, or early in the spring. In winter it may be safely spread over the entire field to prevent an attack. A previous acquaintance with the character, habits, and history of the insect before it makes its appearance among us, must afford much aid in enabling us to meet and successfully combat an enemy that has already caused widespread devastation in regions where it has been permitted to gain a foothold. We hope the worst fears may not be realized, but it certainly looks very much as if there was work to be done. The insect seems as hardy as the common squash-bug, and it is claimed it will live for weeks in solid ice.—*N. E. Farmer.*

SOME of the conclusions of science would indeed be appalling but for their practical harmlessness. Thus, geologists assert that if the continents and the bottom of the ocean were graded down to a uniform level the whole world would be covered with water a mile deep, so much greater is the depression of the ocean bed than the elevation of the existing land.

SELENIUM IN SULPHURIC ACID.

By DR. DRINKWATER, F.C.S.

ON distilling sodic chloride with the selenized acid, as in the manufacture of hydrochloric acid, I found that all the selenium distilled over and was dissolved in the acid, the saline residue being practically free from the impurity.

The results were independent of either temperature or quantity of acid employed. I made experiments leaving both acid and normal salts as the by-products, and in every case the residues were free from selenium; the method employed in testing being to boil up the residue with hydrochloric acid, and pass in sulphurous acid gas, as described in my previous paper.

The sulphuric acid employed was not the artificially selenized acid but some of the original sample, No. 2, which it may be remembered contained 0·38 gramme in 100 c. c.

On boiling a piece of pure copper foil with the impure hydrochloric acid made as described, a deposit was obtained which resembled in all outward appearance the arsenical deposit obtained in a similar manner in Reinsch's test. On heating this in a dry test tube, a sublimate was collected of a distinct crystalline structure, which differed, however, from an arsenical deposit both in the shape of the crystal and in its color. The sublimate dissolved in concentrated sulphuric acid with the characteristic greenish-brown color, and was precipated in red-flakes on the addition of water.

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